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Work Plan for Melville North Landfill

Naval Education and Training Center Newport, Rhode Island

Northern Division Naval Facilities Engineering Command

Contract Number N62472-90-D-1298
Contract Task Order 172

October 1994

Halliburton NUS CORPORATION

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WORK PLAN
FOR
MELVILLE NORTH LANDFILL

NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Submitted to:
Northern Division
Environmental Branch, Code 18
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1.0 INTRODUCTION

The RI/FS is part of an ongoing environmental investigation of the Melville North Landfill site. Site investigation activities at the Melville North Landfill began in 1983 when an Initial Assessment Study (IAS) of this site (and other on-base sites) was conducted by Envirodyne Engineers of St. Louis, Missouri. The IAS revealed the need for additional characterization at the Melville North Landfill and a Confirmation Study (CS), which involved the collection and analysis of environmental samples, was completed by Laururo Engineering Associates of Avon, Connecticut, in 1985. The CS revealed the need for a more comprehensive site investigation of the Melville North Landfill. A Phase I Remedial Investigation (RI) of the Melville North Landfill was completed by TRC Environmental Corporation of Windsor, Connecticut in January 1992. In September 1992, TRC submitted a Draft Phase II Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the Melville North Landfill to the Navy for review. Subsequent to the submittal of the Phase II RI/FS Work Plan, the Navy made a policy decision to complete the environmental characterization work at the Melville North site under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. As directed by the Navy, under the CLEAN Contract No. N62472-90-D-1298 Contract Task Order (CTO) 172, Halliburton NUS Corporation (HNUS) will execute the scope of work to finalize and implement the Phase II RI/FS Work Plan

1.1 OBJECTIVE OF THE RI/FS WORK PLAN

The objectives of the Phase II RI/FS of the Melville North Landfill Site are to:

1) Define the source areas of contamination
2) Define the potential pathways of migration
3) Define the potential receptors and exposure pathways
4) Determine whether a threat to human health or the environment exists and, if so, to what extent
5) Develop and evaluate remedial alternatives

This RI/FS Work Plan details the investigative activities necessary to achieve the RI/FS objectives for the Melville North Landfill Site. It has been written to satisfy the criteria specified in the: Navy/Marine Corps Installation Restoration Manual (February 1992); the HNUS Contract Management Plan C.L.E.A.N. Program (August 1991); the HNUS CLEAN Program Administrative Guidance (December 1991); and the US EPA document entitled: Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA (U.S. EPA, 1988).

The scope and content of the HNUS RI/FS Work Plan are based on the Scope of Work (SOW) supplied by the Navy for CTO 172, except in the instances where a conflict arose between the work prescribed in the SOW and that of the TRC Draft Phase II RI/FS Work Plan or the TRC Response to RIDEM Comments, dated July 1992. When a scope of work conflict was found in these documents HNUS, as instructed by the Navy RPM, used the TRC RI/FS Draft Work Plan scope (or a change in scope agreed to in a response letter, if it superseded or added to the existing Work Plan scope). As explained by the Navy RPM, Ms. Deborah Carlson, this procedure should be employed since it was the Draft Work Plan and the Response to Comments Letter that RIDEM has reviewed and agreed to.

1.2 RI/FS WORK PLAN FORMAT

The following elements are presented in the remaining sections of this document.

- Section 2.0 - Site Background and Setting
- Section 3.0 - Project Plan
- Section 4.0 - Field Sampling Plan
- Section 5.0 - Quality Assurance Project Plan
- Section 6.0 - Data Evaluation and Assessment Plan
- Section 7.0 - Risk Assessment - Human Health Evaluation
- Section 8.0 - Risk Assessment - Ecological Evaluation
- Section 9.0 - ARARs and Preliminary Remedial Action Alternatives
- Section 10.0 - Treatability Study and Feasibility Study Plan

Section 2.0 includes information regarding the known environmental characteristics of the Melville North Landfill site, along with a summary and findings of the studies that were conducted to date.

Section 3.0 focuses on identifying potential or confirmed contaminant migration pathways, identifying potential (or known) impacts to the public health and environment, listing Federal and State ARARs, and evaluating potential remedial technologies/alternatives for mitigating site problems. The purpose of this evaluation is to define site-specific RI/FS objectives. Data or information deemed necessary to identify migration pathways, assess environmental and human health risks, or evaluate the feasibility of remedial actions are identified in this section. This section provides the rationale for development of the work tasks outlined in Section 4.0.

Section 4.0 identifies and describes the tasks and field investigative phases that will need to be implemented to complete the Melville North Landfill RI/FS.

Section 5.0 is the Quality Assurance Project Plan (QAPP) which describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve the project data quality objectives.

Section 6.0 contains the Data Evaluation and Assessment Plan. Data management activities including field sampling documentation, sample management and tracking, analytical reporting, and document control are described. The RI report outline is also presented in this section.

Section 7.0 contains the Human Health Evaluation - Risk Assessment Plan which outlines the processes that will be used to: 1) identify contaminants; 2) assess exposure pathways; 3) assess chemical toxicity; and 4) characterize risks to humans.

Section 8.0 contains the Ecological Evaluation - Risk Assessment Plan which outlines the processes that will be used to perform an in-depth on shore ecological risk assessment of the Melville North Landfill.

Section 9.0 describes the identification of Applicable or Relevant and Appropriate Requirements (ARARs) and the Preliminary Remedial Action Alternatives identified for the Melville North Site.

Section 10.0 describes the Treatability Study/Pilot Testing process and outlines the processes and procedures to be followed for the Melville North Feasibility Study (FS). The outline of the FS report is also presented.

2.0 SITE BACKGROUND AND SETTING

This section presents the history, geology, and hydrology of the Naval Education Training Center (NETC) Newport and the Melville North Landfill site compiled by TRC in their Draft Phase II RI/FS Work Plan. HNUS has excerpted this information and maintained the TRC system of referencing the data that TRC had excerpted from the IAS (Envirodyne Engineers, 1983), and CS (Loureiro Engineering Associates, 1985) relating to the Melville North Site.

The section also presents a brief chronology of the interaction between the Rhode Island Department of Environmental Management (RIDEM), other regulators, and NETC Newport concerning environmental issues at the Melville North Landfill.

2.1 HISTORY OF THE NETC

The NETC is located north of Newport, Rhode Island, (Figure 2-1) on the west shore of Aquidneck Island facing the east passage of Narragansett Bay. The history of the base is as follows:

> The Newport area was first used by the Navy during the Civil War when the Naval Academy was moved from Annapolis, Maryland to Newport in order to protect it from Confederate troops. The Naval Academy operated at Newport for about four years before returning to Annapolis.
>
> In 1869, the experimental Torpedo Station at Goat Island was established. This was the Navy's first permanent activity at Newport. The station was responsible for developing torpedoes and conducting experimental work on other forms of naval ordnance.
>
> In 1881, Coasters Harbor Island was acquired by the Navy from the City of Newport and used for training purposes. In 1984, the Naval War College was established on the island. A causeway and bridge linking the island to the mainland was constructed in 1892. In 1984, the USS Constellation was permanently anchored as a training ship for the Naval War College.
>
> The Melville area was established as a coaling station for the steam-powered ships in 1900. The Navy purchased 160 acres of land and constructed the Narragansett Bay Coal Depot. With the advent of ships burning liquid fuel, it became necessary to add oil tanks. Consequently, in 1910, four fuel oil tanks were added in the Melville area. These tanks are still used today.

In 1913, the Navy established the Naval Hospital on the mainland of Aquidneck Island, directly adjacent to Coasters Harbor Island. At this time, the main hospital building was constructed.

The outbreak of World War I caused a significant increase in military activity at Newport. Some 1,700 men were sent to Newport and housed in tents on Coddington Point and Coasters Harbor Island. A bridge was built at this time connecting Coddington Point with Coasters Harbor Island. In 1918, Coddington Point was purchased by the Navy. Much of the base organization was then transferred to Coddington Point. During the war, numerous destroyers and cruisers were fueled by the Melville coal depot and fuel tanks. By this time, a pipeline had been extended to the north fueling pier and two additional oil tanks constructed.

Following World War I, fuel oil gradually replaced the use of coal by the Navy fleet. In 1921, the Coal Depot was changed to the Navy Fuel Depot. In 1931, the coal barges and coaling equipment were sold to the highest bidder.

In 1923, some two hundred buildings, which were part of the emergency war camps established on Coddington Point, were stripped and sold for scrap. The station was put on caretaker status in 1933. The base remained relatively inactive until the onset of World War II.

Reactivation of the base occurred in the late 1930s as a result of military build-up in Europe. Just prior to the reactivation, a 1938 hurricane and tidal wave had destroyed or severely damaged over 100 buildings and much of the sea walls. In 1940, Coddington Cove was acquired for use as a supply station, and hundreds of Quonset huts were constructed throughout the base. Additional barracks were constructed on Coasters Harbor Island, increasing the base housing capacity to over 3,500 men. Power plant facilities were also constructed at this time. Coddington Point was reactivated to house thousands of recruits. The Anchorage housing complex in the Coddington Cove area was constructed in 1942. In the Melville area, additional fuel facilities were constructed along with a Motor Torpedo Squadron Boat Training Center and nets for harbor defense were constructed. Tank Farms 1 through 5 were constructed during this time period. The Fire Fighting School, Fire Control Training Building, and the Steam Engineering Building were constructed in 1944.

The Torpedo Station at Goat Island was very active during World War II and had expanded its operation to Gould Island. The Torpedo Station employed more than 13,000 people and manufactured 80 percent of all torpedoes used by our country during the war. The station was the largest single industry ever operated in Rhode Island.

Following World War II, naval activities at Newport converted to a peace time status. This resulted in a reduction of naval activity. Some 300 Quonset huts and buildings were removed, and the entire naval complex was consolidated into a single naval command designated the U.S. Naval Base in 1946.

The Naval Base adjusted to its peace time status by increasing its activities in the fields of research and development, specialized training, and preparedness for modern warfare. There was a brief period during the Korean War when some 25,000 sailors trained at Newport.

In 1951, the Torpedo Station was permanently dissolved after 83 years of service. Future manufacture of torpedoes was to be awarded to private industry. In place of the Torpedo Station, a new research and development facility, the Naval Underwater Ordinance Station, was established and given the responsibility of overseeing the private contractors. The Officer Candidate School was also established in 1951.

In 1952, the Training Station and other naval schools were disestablished, and the U.S. Naval Station and the U.S. Naval Schools Command were established.

In 1955, Pier 1 was constructed, with Pier 2 being added in 1957. Newport became the headquarters of the Commander Cruiser-Destroyer Force Atlantic in 1962. Some 55 naval warships and auxiliary craft were homeported at Newport. New housing and bachelor quarters were added in the late 50's and early 60's.

Major expansion of the Naval War College occurred during the late 50's and early 70's, transforming the college into a major university. In July of 1971, the Naval Schools Command was restructured and named the Naval Officer Training Center (NOTC).

In April of 1973, the Shore Establishment Realignment Program (SER) was announced and resulted in the largest reorganization of Naval forces in the Newport area. The fleet stationed in Newport was relocated to other naval stations on the east coast. SER resulted in the termination of the Naval Communication Station and the Fleet Training Center and related activities. The Public Works Center, Naval Supply Center, Naval Station and Naval Base were absorbed by NOTC. In April of 1974, NOTC was changed to the Naval Education and Training Center (NETC).

The drastic changes which resulted from SER caused a reduction of Navy personnel, both military and civilian, in excess of 14,000. Coupled with the reductions at the Naval

Construction Battalion Center at Davisville, and the closure of the Naval Air Station at Quonset Point, SER had severe economic impacts in the Narragansett Bay area.

The reorganization brought about by SER resulted in the Navy excessing some 1,629 acres of its 2,420 acres. Some of the land has been leased to the State of Rhode Island pending final sale of the land by the General Services Administration. Table 1 [in IAS] shows an area by area breakdown on land holdings prior to SER and following. The Navy also leases 44 acres of land in Coddington Cove to the State of Rhode Island and Economic Development Corporation. The state has subleased this property to a private enterprise engaging in shipbuilding and repair. Also, a fish food processing operation utilizes the cold storage warehouse in Building 42 near Pier 1. (Both the shipbuilding and repair facility and the fish food processing operations have been abandoned and are currently being investigated by the Navy under a SASE.)

The above information on the history of the installation was obtained from the most recent Master Plan (NORTHDIV, 1980), the 1981 Annual Report of the Navy in the Rhode Island Area (NETC Public Affairs Office, 1981), and the Command Histories at the Naval History Office in Washington, DC.

(Reference IAS, pp. 5-6 to 5-14)

2.1.1 Melville North Landfill Site History

The Melville North Landfill site was investigated in both the IAS and CS. The following site history information was obtained from the IAS report.

The site was used as a landfill for at least the period following World War II until 1955. The date that the site first began to be used as a landfill is unclear, but all indications are that it was after the war. Following its closure in 1954, wastes generated at the naval complex were disposed of at the McAllister Point Landfill. The site encompasses approximately 10 acres.

The Melville North Landfill would have received wastes similar to those which were disposed of in McAllister Point Landfill, including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube) and, potentially, PCBs. The quantity of these wastes disposed of in the landfill is unknown. During visual inspections of the site, areas covered with oil and oil sludge were found to be scattered throughout the site. There were mounds of oil-soaked soil which appeared to have been trucked to the site and dumped. These oil-contaminated mounds could

be the oil sludge materials obtained from the tank farms during tank cleaning operations, or the result of cleanup operations following oil spills.

The site is situated in the Melville North area in a low-lying wetland type area along the shoreline of Narragansett Bay, as shown in Figure 1-2 [Figure 1-2 is not shown in the IAS report - see Figure 2-1 of this work plan]. The area is subject to periodic flooding and lies within the 100-year flood plain [NETC Master Plan, 1986]. This site is located on land which is being excessed by the Navy and is pending final disposal by GSA.

(Reference IAS, pg. 6-34)

The site was excessed by the Navy in September 1983 to the State of Rhode Island. Six months later, the site was sold to Melville Marine Industries. Melville Marine Industries currently plans to develop the site as a marina.

2.2 REGIONAL PHYSIOGRAPHY

This section is divided into three subsections: climate, terrestrial features, and marine features. Regional geology and hydrology will be addressed in separate sections following this discussion. Additional site-specific studies regarding site terrestrial and marine features will be performed under the Phase II Ecological Risk Assessment.

2.2.1 Climate

The climate at NETC Newport is presented below. Much of the climatological information was obtained from the IAS report, and is referenced as such with page numbers that follow excerpts.

The climate at NETC is greatly influenced by its proximity to Narragansett Bay and Atlantic Ocean, which tend to modify the area's temperatures. Winter temperatures are somewhat higher and summer temperatures lower than more inland areas. Winters are moderately cold in the area, and summers are generally mild with many summer days cooled by sea breezes. .

The average annual precipitation for the area is 42.75 inches, but this has varied from as little as 25.44 inches to as much as 65.06 inches. Measurable precipitation (.01 inch or greater) occurs on about one day out of every three and is evenly distributed throughout the year. Thunderstorms are responsible for much of the rainfall from May through August. These thunderstorms often produce heavy amounts of rainfall, but their duration is relatively short.

Summer thunderstorms are frequently accompanied by high winds which may result in property damage, especially to small boats. The average snowfall during winter is close to 40 inches, ranging from a low of 11.3 inches to a high of 75.6 inches. February is usually the month of greatest snowfall, but January and March are close seconds. It is unusual for the ground to remain snow covered for any long period of time. . . .

Severe weather from tropical cyclones (winds 39 to 73 miles per hour) and hurricanes (winds greater than 73 miles per hour) is a serious threat in the area of NETC. The probability that a tropical cyclone will invade the area is one in five in any year, while the probability of hurricane force winds invading the area is less than one in fifteen in any year (Outleasing EIS, 1977). The most damage from these severe storms results when they strike at high tide.

(Reference IAS, pp. 5-14 to 5-15)

2.2.2 Terrestrial Features

The topography of the NETC area was shaped by the bedrock geology, glaciation, and recent erosion. The bedrock geology controlled the locations of the ancient river valleys, which glaciers subsequently gouged out of the bedrock. The hills are the result of bedrock highs. A mantle of till, on average 20 feet thick, was spread over the bedrock during the Wisconsin glaciation. As the glaciers melted, ocean levels rose and flooded the river valleys forming the passages of Narragansett Bay.

Elevations at NETC range from near mean sea level to 175 feet in the Melville North area. Many areas of NETC have low elevations which are susceptible to flooding during hurricane storm surges. The 100 and 500 year tidal flood elevations for the NETC area are 12.6 feet and 15.6 feet above mean low water, respectively. Areas below these elevations are subject to flooding.

Ninety percent of the land within the boundaries of NETC has slopes of from 0 to 9 percent (Master Plan, 1980). The remaining land has slopes in the categories of 10 to 25 percent and greater than 25 percent. Maps showing slopes on all NETC areas are included in the most recent Master Plan for NETC.

(Reference IAS, pg. 5-15)

The soils in the area of NETC formed in glacial deposits of till and outwash. . . . There are also a few areas with tidal marsh soils along the shores of Narragansett Bay. These tidal marsh

areas receive deposits of silt and clay during tidal inundation and from upland areas. These sediments are deposited along with the plant remains of the salt tolerant plants growing in the marshes.

(Reference IAS, pg. 5-21)

According to TRC, five basic soil types are found at the NETC: mucks, beaches, loams, sands, and urban complexes. The mucks are found in tidal flats and inland depressions that hold ponded water. Loams (mixtures of sand, silt, clay, and organic matter) and sands are found in upland areas on-site and generally drain rapidly. Urban complexes are mixtures of natural soils, imported soils, and urban materials.

> The flora and fauna of the NETC is strongly influenced by human activity. The southern portion of the base is heavily industrial with machine shops and other support facility operations. The north portion of the base is divided in land usage between residential, vacant (held for expansion), tank farms, and storage-fueling facilities (industrial). There are no land areas on NETC which have not been disturbed at some time during base operations. . . .
>
> Southern Rhode Island has relatively few forests of mature climax successional stage. Fires, logging, and the agricultural conversion of forest land prior to the Civil War have greatly reduced the extent of climax forest acreage. The predominant forest vegetation in southern Rhode Island is that of abandoned fields in early successional stages, and forests of immature hardwoods. Pure stands of mature softwoods are the least abundant. . . .
>
> The upland vegetation within the NETC is restricted primarily to perennial weeds and grasses. The majority of trees is located near residences, drainageways and around the tank farms. The upland vegetation of NETC reflects complete management (mowing) or recent disturbance of the area.
>
> The habitats available for lowland vegetation on the NETC are located on the waterfront along Narragansett Bay and surrounding the small impoundments and their drainages further inland. Those areas located on the waterfront are comprised of borrow pits along the railroad tracks and abandoned disposal areas where excavation has created depressions.
>
> The largest of these depressions is the Melville North landfill. This area was excavated during landfill operations and depressions were created. These depressions support a limited diversity of wetland flora including reeds and various shrub and grass species. Borrow pits can be found

along the railroad tracks which parallel the shoreline extending from McAllister Point northward to the Melville North landfill. These are individually less than one acre in size and contain similar wetland species with a lack of diversity.

All lowlands on NETC have been artificially created and are in a disturbed condition. The potential for maintaining diversified floral species within the lowlands of NETC is poor. This area did not previously contain these habitats, and sills and drainage are not conducive to their successional development.

The fauna of the region have been affected by similar disturbances (clearing, excavation, construction) which led to the impoverishment of the flora. Field studies have indicated impoverished fauna, particularly of herptile and mammal types. Widespread habitat destruction over a period of several hundred years has caused emigration or elimination of many species. As a result, the present regional fauna consist primarily of species of wide distribution and ecological tolerances, high adaptability, and nonrestrictive habitat requirements.

No large animals such as deer, turkey, or cougar are known within the boundaries of NETC. However, red fox, raccoon, rabbit, and gray squirrel are present in the woodlands.

Mammalian forms expected to be found on base include: the Eastern chipmunk, New England cottontail rabbit, white-footed mouse, short tailed shrew, gray squirrel, and red squirrel. Several of these species inhabit the few remaining wooded areas on base slated to be excessed.

Various herptiles occupy NETC habitats. Common ones include the red backed salamander, American toad, wood frog, eastern gartersnake, northern black racer and the wood turtle.

Common herptiles of the wet areas include the American toad, spring peeper, bullfrog and northern watersnake (Natrix sipedon), along with the snapping turtle. Avian species which may be found within the NETC upland habitats include the bobolink, meadowlark, chimney swift, kingbird, eastern phoebe (Sayorius phoebe), barn shallow, red-tailed hawk and kestrel.

In addition, game birds, such as the ring-necked pheasant, bobwhite quail and the mourning dove, are highly dependent on the plant communities on the base.

(Reference IAS, pp. 5-37 to 5-39)

2.2.3 Marine Features

The Narragansett Bay marine features are presented below. Much of the information about marine features was obtained from the IAS report, and is referenced as such with page numbers that follow excerpts.

> Narragansett Bay occupies three former river valleys which have been drowned by the advance of the Atlantic Ocean. Narragansett Bay is 20 miles long and 11 miles wide. The bay has a surface area of 102 square miles. Figure 5.3-7 (not shown in this Work Plan) shows Narragansett Bay and the surrounding areas. The shape of the former river valleys has changed little since the last glaciation. The bay is divided into an eastern and western passage by Conanicut Island. The average depth of the bay is 30 feet. In the western passage, the average depth is 25 feet, while in the eastern passage, the average depth is 50 feet. The eastern passage, which NETC fronts, allows deep water access up to the south end of Prudence Island. Channel depth exceeds 80 feet in the eastern passage from Gould Island seaward, and depths in excess of 150 feet occur near the mouth of the bay.
>
> Freshwater flows into the bay at an average rate of 1,239 cubic feet per second from a drainage area of 1,850 square miles. This accounts for 90 percent of the annual flow of fresh water into the bay. The other 10 percent is provided by direct rainfall into the bay and sewage effluent. An average of some 43 inches per year of precipitation falls directly into the bay. The freshwater input into the bay is small compared to the large volume of saline water in the bay. The relatively small freshwater input into the bay results in the bay water being well mixed with only small salinity gradients through the bay. Salinities range from about 22 parts per thousand (ppt) in the Providence River to 32 ppt at the mouth of the bay.
>
> Tides are semi-diurnal in Narragansett Bay with a mean range of 3.6 feet at the mouth of the bay and 4.6 feet at the head. Abut 13 percent of the volume of water in the bay is exchanged each tidal cycle (Oviatt and Nixion, 1973). This is over 250 times the mean tidal river flow into the bay during a tidal cycle. The tidal movement is the single most important factor in water circulation in the bay. Tidal currents range in velocity from 0.07 to 2.3 feet per second (Atlantic Scientific, 1982). The faster velocities occur in the east and west passages near the mouth of the bay, while slower velocities occur in the upper bay.
>
> Non-tidal current in the bay moves slowly at an average of 0.34 feet per second (Olsen, 1980). Although the non-tidal currents are slow, they are important in the exchange of water out of the bay and into Rhode Island Sound. The amount of time needed to transport a particle of

water from Providence to the mouth of the bay is some 45 to 50 days (Olsen, 1980). However, this time can vary depending on the winds. Research seems to indicate that southeast winds blowing up the bay may prevent surface waters from flowing down the bay (Olsen, 1980).

The water quality for Narragansett Bay as determined by the State of Rhode Island is shown in Figure 5.3-8 [not shown in this document]. Most of the bay is Class SA, which means it suitable for direct shellfish harvesting, bathing and other water contact sports. Areas classified as SB are suitable for shellfish harvesting after depuration and for bathing and other recreational activities. Areas classified as SC are suitable for fish, shellfish, and wildlife habitat areas, but the shellfish cannot be harvested. The entire shoreline of NETC is closed to shellfishing.

(Reference IAS, pg 5-28, 5-31)

The marine ecosystem of Narragansett Bay forms the shoreline of the base for approximately 9 miles. The bay is of great economic and aesthetic importance of the entire southern portion of Rhode Island. It is an estuary and the fishery resources of the bay are extremely important. The annual value of the combined commercial and sport fishing is estimated at several million dollars.

In Narragansett Bay, the phytoplankton are by far the most important primary producers, synthesizing organic matter from carbon dioxide and inorganic nutrients with sunlight as the energy source. In shallower, less turbid estuaries, seaweeds and sea grasses may assume this role. . . .

The phytoplankton and zooplankton are rich and varied in Narragansett Bay. The species composition is relatively uniform from station to station indicating a good movement of the water mass within the bay. The estimated productivity figure of 84 grams of carbon per square meter per year is also indicative of good environmental conditions. . . .

Most species of finfish move in and out of Narragansett Bay following well established seasonal patterns. These migratory movements, although different for each species, provide for distinct summer and winter populations of finfish. The migrations are related primarily to temperature, and the major shifts between winter and summer populations take place when the water temperature is about 10°C (50°F).

Narragansett Bay is visited each year by a great many species of fish because it lies along the boundary between southern and northern populations. Thus, herring from Georges Bank may visit the bay at the end of their southward midwinter migrations, and species such as scup and occasional exotic tropical strays brought up by the Gulf Stream make their appearance during the summer. In all, over 100 species may appear in any given year, about half of which are occasional visitors.

In various studies during the 1970's a total of 99 species of fish have been taken from Narragansett Bay (Oviatt and Nixon, 1973; Jeffries and Johnsons, 1974; Camp, Dresser and McKee, 1978; Department of the Navy, 1978). Ten species accounted for 91 percent of the fish catch with the winter flounder, the sand dab, scup and butterfish the most commonly occurring fish taken. These four species are also of commercial importance. . . .

A year-long, bay-wide survey (excluding Mount Hope Bay and the Sakonnet River) of bottom fish made in 1972 yielded an annual minimum estimate of 117 individuals, or 28.5 pounds per acre. This translates into a standing crop of 1.9 million pounds of bottom fish. (The margin of error gives a range of 0.8 to 2.9 million pounds.) This is comparable to other estimates made using similar sampling techniques in New England estuaries and offshore fishing grounds. This bay-wide survey showed that despite the constant movement of species in and out of the bay, the total biomass of bottom fish is remarkably steady.

There are fewer species of pelagic fish than of bottom fish in the bay, but they make up for this by their numbers and their importance to fishermen. All the pelagic species are highly seasonal, with anchovies and sea herring appearing in the winter, and menhaden, bluefish, and striped bass in the summer. When schools of menhaden are present, their biomass may be far greater than that of the bottom fish. Population estimates for the bay are for as much as 16 million pounds of menhaden and 2 million pounds of bluefish and stripers. . . .

The benthic community in Narragansett Bay plays a critical role in the functioning of the ecosystem. Benthic filter feeders consume significant amounts of phytoplankton, and the bay's high primary productivity may be attributable in good part to the recycling activity of the benthos. . . .

The shellfish of Narragansett Bay include both bivalve molluscs (clams, oysters, scallops) and decapod crustaceans (crabs, shrimp, lobster). Lobster are caught both within and outside of Narragansett Bay. Lobsters are trapped in much of Narragansett Bay including the Coddington Cove area. Some lobster traps are located a short distance from Pier 2.

Bivalves harvested in the region of Narragansett Bay include the northern quahog (known as they bay quahog in Rhode Island), soft shell clam, and Atlantic bay scallop.

The quahog is the most valuable shellfish resource within the bay system. The number of people harvesting this organism for individual or commercial use is increasing. Shellfishing areas open to the public do not include the NETC shoreline.

Quahogs are the most abundant benthic animal of their size in Narragansett Bay (URI, 1980, Bulletin #40). In recent years, the total Rhode Island harvest ranged from 5 million pounds of meats in 1955 to 2 million pounds in 1978, the great majority of which are taken from the bay. . . .

Water pollution continues to take a heavy toll in the reduced numbers of quahogs available for harvesting. The primary criterion used in closing areas to shellfishing is the abundance of fecal coliforms in the water; these are an indicator of sewage and the pathogenic bacteria and viruses it may contain. A shellfish depuration plant is capable of killing harmful microorganisms that might be found within the shellfish, but not has been built in the bay area. Unfortunately, pathogenic microorganisms are only one aspect of the pollution in the upper bay. There are signs that Providence River quahogs are not healthy and may be dying off at least in some areas. Several researchers are concerned that they may be accumulating significant levels of petroleum or heavy metals, which are not removed by the usual depuration methods.

Aquaculture within the bay includes the eastern oyster and the blue mussel. Two species of clams are harvested offshore and landed at bay fishing ports. They are the Atlantic surf clam and the ocean quahog. Most of the northern areas of the bay are closed permanently or opened on a conditional basis. Most of the lower bay localities are opened. The shellfish area just south of the Newport Naval Facility is permanently closed because of municipal sewage discharge.

(Reference IAS, pp. 5-40 to 5-47)

2.3 REGIONAL GEOLOGY

The regional geology for NETC Newport is presented below. Much of the geological information was obtained from the IAS report, and is referenced as such with page numbers that follow the excerpts.

NETC is located at the southeastern end of the Narragansett Basin. This basin is a complex synclinal mass of Pennsylvanian aged sedimentary rocks and is the most prominent geologic feature in eastern Rhode Island and adjacent Massachusetts. Narragansett Basin is an ancient north to south trending structural basin originating near Hanover, Massachusetts. The basin has a length of approximately 55 miles and varies from 15 to 25 miles wide. The western margin of the basin is in the western portion of Providence, Rhode Island, and the eastern margin runs through Fall River, Massachusetts. Exposures of older rocks on Conanicut Island and in the vicinity of Newport suggest that the southern extent of the basin is near the mouth of Narragansett Bay.

The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The rocks are chiefly conglomerates, sandstones, shales, and anthracite. Total thickness of the strata in the Narragansett Basin has been estimated at 12,000 feet. Both vertical and lateral irregularities in the lithologic character of the rock are present within the basin. Many folds and some faults occur throughout the basin, but the character and amount of the folding and faulting are not clearly known. The sedimentary rocks of the basin are believed to have been deposited in a lowland area which was surrounded by an upland area of considerable relief. The presence of coal beds within the basin also indicates that there were fairly extensive swampy areas. . . .

The bedrock of the Narragansett Basin has been divided into the following five units: the Rhode Island Formation, Dighton Conglomerate, Wamsutta Formation, Pondville Conglomerate, and Felsite at Diamond Hill. AT NETC and most of the surrounding area, the bedrock is entirely of the Rhode Island Formation, and thus, only this unit will be examined in detail. . . .

The Rhode Island Formation is the most extensive and thickest of the Pennsylvania formations in Rhode Island. The vast majority of the Narragansett Basin is underlain by this formation. Included within the Rhode Island Formation are fine to coarse conglomerate, sandstone, lithic graywacke, graywacke, arkose, shale and a small amount of meta-anthracite and anthracite. Most of the rock is gray, dark gray, and greenish, but the shale and anthracite are often black. Crossbedding and irregular, discontinuous bedding is characteristic of the formation. Rocks of the Rhode Island Formation, which are in the northern portions of the basin, are strong and indurated but are not metamorphosed. However, those rocks in the southern portion of the basin, such as the NETC, are metamorphosed, and these rocks contain quartz-mica schist, feldspathic quartzite, garnet-stacrolite schist, and some quartz-mica-sillimanite schist. The beds of meta-anthracite and anthracite are mostly thin, but many areas within basin have been

mined. Vein quartz, fibrous quartz, and pyrite are commonly associated with these coal layers, and the ash content is high.

Within the Rhode Island Formation, there are a few areas of thick conglomerates. These conglomerate layers are gray to greenish in color and are mostly very coarse. These conglomerates consist of pebbles, cobbles, and boulders (up to several feet long), interbedded with sandstone and graywacke. The stones are predominantly quartzite and have been elongated as a result of tectonic forces in the southern portion of the basin. These thick conglomerate layers are more resistant to erosion than are the surrounding rocks and thus, are topographically higher. Coasters Harbor Island is mostly covered with this conglomerate material.

Throughout the Narragansett Basin, the Pennsylvanian rocks are underlain by pre-Pennsylvanian igneous and metamorphic rocks such as Bulgarmarch granite, Metacom granite gneiss, porphyritic granite and slate and quartzite. For the most part, these basement rocks are deeply buried beneath the Pennsylvanian rocks. However, these older rocks occur north of NETC in the Bristol area and south of NETC in the Fort Adams and Newport Neck areas and on the southern tip of Conanicut Island. Rose Island and Goat Island also have older metamorphic rocks of slate and quartzite.

Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments. These Pleistocene sediments owe their origin to the Wisconsin glaciation which covered the area with ice several thousand feet thick. As the glaciers receded some 10,000 to 12,000 years ago, they deposited unconsolidated glacial materials of variable thicknesses throughout the Narragansett Basin area. The unconsolidated glacial material ranges from 1 to 150 feet thick, being thicker in the valleys and thinner in the uplands. The glacial material consists of till, sand, gravel, and silt. These glacial deposits were derived from shale, sandstone, conglomerate, and in a few places, coal. The glacial materials serve as the parent materials for the soils in the area. Areas where sand and gravel were deposited serve as important regional mineral sources. . . .

(Reference IAS, pp. 5-18, 5-21)

Much of the geologic information contained in this section was obtained from Geological Survey Bulletin 1295 (Quinn, 1971). . . .

(Reference IAS, pg. 5-21)

Several soil borings were completed into bedrock as part of a Remedial Investigation conducted at four RI/FS sites within the NETC (TRC, 1991). Bedrock was encountered at four of the RI sites. Generally, the bedrock consisted of a grey-green to black, highly weathered to competent, carboniferous shale. Rock cores indicated a high degree of fracturing with quartz and iron oxide deposits present along the fracture planes. Depth to bedrock varied amongst boring locations from approximately one to 33 feet below ground surface.

Glacial till deposits were encountered overlying the bedrock at NETC during the RI investigations. The till material was characterized as containing fine to coarse sand with varying amounts of silt, with some horizons containing weathered shale fragments. A single Shelby Tube sample of the till indicated a triaxial permeability of 2.7×10^{-7} cm/sec (7.7×10^{-4} feet/day). Natural deposits of sand and silt and organic muck were also encountered.

2.4 REGIONAL HYDROLOGY

The regional hydrology for NETC Newport will be discussed in two following subsections covering surface water and groundwater.

2.4.1 Regional Surface Water Hydrology

The regional surface water hydrology for NETC Newport is presented below. Much of the regional information was obtained from the IAS report, and is referenced as such with page numbers that follow the excerpts.

> NETC is located within the Narragansett Bay Drainage Basin. This drainage basin covers an area of 1,850 square miles, 1,030 square miles of which are in Massachusetts and 820 square miles of which are in Rhode Island. All surface water drainage from the basin is into Narragansett Bay. Three major rivers, the Taunton, Blackstone, and Pawtucket, as well as the Providence River and a number of smaller rivers and streams, drain into Narragansett Bay. Discharge from Narragansett Bay is into the Atlantic Ocean between Point Judith and Sakonnet Point in Rhode Island.
>
> Throughout NETC, the surface drainage is westward toward Narragansett Bay with the exception of one area in Tank Farm #2 which drains eastward into Melville Reservoir. Surface drainage at NETC is provided by the Melville Ponds, Normans Brook, Lawton Brook and Reservoir, Gomes Brook, a stream and pond in the northeastern portion of NUSC, and a stream

discharging into Coasters Harbor. The surface drainage for NETC is shown in Figure 5.3-6 (not shown in this document). All these streams discharge into Narragansett Bay. . . .

Except for the stream and pond at NUSC and the stream which empties into Coasters Harbor, all of the other streams and ponds are on land which is being excessed by the Navy. The Melville Ponds have been disposed of by GSA and are now part of the Melville Public Fishing Area.

While these streams and ponds receive drainage from many of the areas within NETC, a substantial portion of the NETC area drains directly into Narragansett Bay or infiltrates into the soil before reaching a stream or body of water. Direct runoff into Narragansett Bay would especially occur following thunderstorms. . . .

(Reference IAS, pp. 5-26, 5-28)

The potential for pollutant migration by surface drainage at NETC is greatly increased by its proximity to Narragansett Bay. Many of the waste disposal areas, such as the McAllister Point landfill, Melville North disposal site and Gould Island disposal site, are located right along the shoreline of Narragansett Bay. Surface drainage from these areas is directly into the bay. The NETC area is frequently subjected to thunderstorms during which intense periods of rainfall are common. Surface drainage into the bay would be greatest following these thunderstorms.

Pollutants from these portions of NETC drain into the Melville Ponds, Normans Brook, Lawton, Brook, Gomes Brook, and the NUSC stream and would also migrate off-site. All of the streams discharge directly into Narragansett Bay.

(Reference IAS, pg. 5-34)

2.4.2 Regional Surface Water Classifications

Most of Narragansett Bay, as determined by RIDEM, is classified as Class SA, which means it is suitable for bathing and contact recreation, shellfish harvesting for direct human consumption, and fish and wildlife habitat.

Areas classified as Class SB are suitable for public drinking water with appropriate treatment, agricultural uses, bathing, other primary contact recreational activities, and fish and wildlife habitat.

Areas classified as Class SC are suitable for boating, other secondary contact recreational activities, fish and wildlife habitat, industrial cooling, and have good aesthetic value.

Two freshwater streams located on NETC property have been classified as Class B surface waters. Class B surface waters are suitable for public water supply with appropriate treatment, agricultural uses, bathing, other primary contact recreational activities, and fish and wildlife habitat.

2.4.3 Area Water Use

Public water in the City of Newport and Town of Middletown is supplied and managed by the Newport Water Department. The Town of Portsmouth purchases water from the Newport Water Department but operates its own distribution system. Approximately two-thirds of Portsmouth is serviced by public water, with the remaining one-third supplied from private water wells. While no specific records exist as to private well use in the information reviewed, in general, the majority of private wells are reportedly located on the eastern portion of Aquidneck Island (personal communication, Town of Portsmouth, 1992).

The Newport Water Department receives its water supply from a series of seven surface water reservoirs located on Aquidneck Island, two surface water reservoirs on the mainland, and is connected to both the Tiverton and Fall River reservoirs.

The seven surface water reservoirs on Aquidneck Island are:

1. Lawton Valley Reservoir,
2. St. Marys Pond,
3. Sisson Pond,
4. Easton North Pond,
5. Easton South Pond,
6. Paradise or Nelsons Pond, and
7. Gardners Pond.

Each of these reservoirs is supplied water via rainfall and runoff and is not augmented by ground water supply wells. The Newport Water Department stated that the safe yield of the reservoir system is approximately 11 to 13 million gallons per day (MGD). Water use in 1991 was 7.07 MGD, and adequate capacity reportedly exists for projected water usage on Aquidneck Island for the next ten to twenty years, or more (personal communication, Newport Water Department, 1992).

The Prudence Island Utilities Company supplies ground water to approximately 800 people on Prudence Island, Portsmouth, located east and off-shore of the Melville area.

Private wells are reported to withdraw water from till, bedrock, and stratified-drift aquifers. Of these aquifers, bedrock is considered the most reliable source of ground water, and well yields are commonly sufficient for domestic supplies (Johnston, U.S.G.S., undated).

The location, depth, and yield of private bedrock wells in the Prudence Island and Newport Quadrangles are contained in the IAS report. The IAS report indicated that bedrock wells in the area range from approximately 14 to 1,300 feet deep. Well yields from 55 gallons per minute (GPM) to less than 1 GPM are reported in the IAS report.

2.4.4 Regional Groundwater Hydrology

The regional ground water hydrology for NETC Newport is presented below. Much of the regional information was obtained from the IAS report, and is referenced as such with page numbers that follow the excerpts.

> Many areas on Aquidneck Island, on which NETC is located, obtain their water supply from wells. Areas relying on ground water are mostly north of the Middletown area, but there are wells throughout the entire island. Most ground water is used for domestic needs, although some is used by small industries and businesses.
>
> Ground water on Aquidneck Island is obtained from the unconsolidated glacial deposits of till and outwash and from the underlying Pennsylvanian bedrock. Throughout the area, depth to ground water ranges from less than one foot to about 30 feet, depending upon the topographic location, time of year, and character of subsurface deposits. The average depth to the ground water is around 14 feet on Aquidneck Island and moves from areas of high elevations to Narragansett Bay or the Sakonnet River.
>
> Seasonal water level fluctuations are common in the area. These fluctuations range from less than 5 feet to as much as 20 feet on the hills. In the valleys and lowland areas, the fluctuations are generally less than 5 feet. During the late spring and summer, the water table usually declines as a result of evaporation and the uptake of water by plants, and rises during autumn and following winter thaws.

The unconsolidated glacial deposits range in thickness from less than one foot near the rock exposures to about 50 feet throughout Aquidneck Island. Most of the glacial deposits are till, but isolated outwash areas occur. In the NETC area, the glacial deposits are till with a thickness of less than 20 feet. Wells completed in the till are usually dug and range in depth from less than 10 feet to as much as 75 feet. The average depth for these wells is about 20 feet. These dug wells are usually 2 to 3 feet in diameter and are usually dug down to the top of the bedrock.

The yield of till wells varies considerably depending upon the type and thickness of the water-bearing deposits penetrated. Yields range from less than one to as much as 120 gallons per minute. Under normal weather conditions, till wells yield a few hundred gallons of water per day and are adequate for domestic supplies. The large diameter of dug wells also provides substantial water storage area between periods of use. Each foot of water in a 3-foot diameter well represents storage of 53 gallons. However, these wells are subject to going dry during seasonal or unusual droughts.

Bedrock wells in the area range from 14 to 1,300 feet in depth. The average depth for these bedrock wells is 135 feet. Yields from bedrock wells range from less than one to as much as 55 gallons per minute. Most wells yield less than 10 gallons per minute. The yields vary considerably in the bedrock over short distances because the joints and fractures which transmit water to the wells occur intermittently. Joints and fractures are most numerous and widest near the top of the bedrock and become fewer and narrower with depth. Bedrock wells seldom go dry, but yields can be extremely low if not enough fractures and joints occur in the area of the well.

The chemical characteristics of the ground water are similar throughout the area, and the water is generally satisfactory for most ordinary uses. Most ground water in the area is soft or only moderately hard, with ground water from till generally containing less mineral matter and being softer than ground water from bedrock. Areas where the ground water has high iron content are scattered throughout the area, being most numerous around Newport and Middletown and the northern part of Portsmouth. Wells which have a high iron content usually penetrate only rocks of Pennsylvanian age.

In scattered locations near the shoreline, over-pumping has led to salt water intrusion in some wells. Bedrock wells are not as easily contaminated with salt water as are till wells, but the chance of contamination increases as the depth of the well below sea level increases.

No wells were identified within the boundaries of NETC other than on Gould Island, although there are numerous wells in close proximity. These wells are upgradient of NETC. . . .

(Reference IAS, pp. 5-31 to 5-34)

The ground water at NETC is very shallow, being less than 10 feet below the surface in most areas. This shallow depth makes ground water contamination at NETC very possible. Those pollutants which do find their way into the ground water would migrate to the west and discharge into Narragansett Bay. NETC extends along the western shoreline of Aquidneck Island, and the ground water only has to migrate a short distance before discharging into Narragansett Bay.

The soils occurring at NETC have permeabilities which are moderate to moderately rapid, and they do not restrict the vertical movement of water. The glacial till, from which these soils were derived, is generally less permeable than the overlying soils but does not represent a barrier to the vertical migration of water. Therefore, it is possible that any contaminant transported in this water could contaminate the ground water. There are also isolated areas where the bedrock occurs at the surface. Contamination is possible in these areas through the cracks and fissures which commonly occur in the bedrock.

(Reference IAS, pg. 5-34)

Information obtained from the Phase I Remedial Investigation indicated that, groundwater under Melville North Landfill flows from east to west toward Narragansett Bay. Depth to ground water ranged from approximately 4 to 19 feet below ground surface at the Melville North Landfill site. Slug tests conducted on monitoring wells at these sites indicated that the hydraulic conductivity of the till unit ranged from 0.22 to 0.44 feet per day and upper bedrock hydraulic conductivity ranged from 0.029 to 0.21 feet per day. The RI report noted that bedrock test data produced hydraulic conductivities higher than those normally attributed to shale (3.28×10^{-4} to 3.28×10^{-8} feet per day (Driscoll, 1987)).

2.4.5 Groundwater Classifications

RIDEM has classified ground water in Rhode Island in order to protect and restore the quality of the state's ground water resources for use as drinking water and other beneficial uses, and to assure protection of the public health and welfare, and the environment.

Ground water classified GAA includes those groundwater resources that the RIDEM Director has designated to be suitable for public drinking water without treatment and that are located in one of the three following areas:

1. Groundwater reservoirs and portions of their recharge areas as delineated by RIDEM;

2. A 2,000 foot radius circle around each community water system well or within the delineation of a wellhead protection area to each well delineated by RIDEM;

3. Groundwater dependant areas, such as Block Island, that are physically isolated from reasonable alternative water supplies and where the existing ground water supply warrants the highest level of protection.

Groundwater classified GA is known or presumed to be suitable for drinking water without treatment. Areas that are unclassified are presumed by RIDEM to be Class GA groundwater.

The groundwater under the Melville North Landfill site has been classified as Class GB. Ground water classified GB may not be suitable for drinking water without treatment due to known or presumed degradation. GB classified groundwater is primarily located at highly urbanized areas or is located in the vicinity of disposal sites for solid waste, hazardous waste, or sewerage sludge.

2.5 MELVILLE NORTH LANDFILL SITE DESCRIPTION

The Melville North Landfill is located at the northern end of the Newport Naval Base (Figure 2-1). The site is approximately 8 acres and is situated between Defense Highway and Narragansett Bay (Figure 2-2). Penn Central Railroad tracks run in a north-south direction on the eastern side of the site. Access to the site is off of Defense Highway through a small gate and along a paved entrance way. The paved entrance way leads approximately 180 feet down a small hill and across the railroad tracks to the site. A map of the site is presented on Figure 2-2.

The central and northern portions of the site are relatively flat. A slight ridge runs along the eastern half of the southern portion of the site.

Ground elevations across the main portion of the site vary between approximately 10 and 20 feet above mean sea level. The grade along the western edge of the site is nearly level with the shoreline. Between the site and the Defense Highway, the elevation increases approximately 40 feet (Figure 2-2).

The site is vegetated with grass, weeds, and some small trees. A strip of small trees is present along the edge of the bay in the west-central portion of the site. A small, more densely wooded area is present along the edge of the bay in the southern portion of the site. A wooded area is present just off the central and southern edge of the site, between the site and Defense Highway. The Navy routinely clears vegetation along the overhead power lines that run along the eastern edge of the site.

2.6 CHRONOLOGY OF REGULATORY AND NAVY ACTIONS

The following chronology pertinent to the Melville North Landfill site investigation was obtained from the IAS report, the Confirmation Study, the TRC Phase I RI/FS information supplied by the Navy, and a review of information in RIDEM files:

Unknown Date - The entire NETC shoreline (including the Melville North Landfill shoreline) was closed to shellfishing due to concerns about bioaccumulation of contaminants in Narragansett Bay from sites on the facility.

September 11, 1980 - the Navy Assessment and Control of Installation Pollutants (NACIP) program was initiated. The purpose of the program is to systematically identify, assess, and control environmental contamination from past use and disposal of hazardous substances at Navy and Marine Corps installations.

March 1983 - Initial Assessment Study (IAS) of NETC (including the Melville North Landfill) was completed.

May 1986 - Confirmation Study Report (CS) on the NETC (including the Melville North Landfill) was completed.

1991 - Phase I RI/FS Report on five sites at the NETC (including the Melville North Landfill) was completed.

1993 - Oily soil piles removed from northern end of site. Approximately 800 cubic yards of soil and 100 cubic yards of railroad timbers were removed and sent to approved treatment and disposal facilities.

1993 - Offshore sampling of sediment, clam, and mussels conducted at the Melville North Landfill.

3.0 PROJECT PLAN

This section of the Work Plan presents: 1) the conceptual model (based upon our current level of understanding) of the environmental conditions at the Melville North Landfill site; 2) our current understanding of the risks that these conditions represent; 3) the preliminary identification of the applicable response objectives and remedial action alternatives; and 4) the rationale for the data collection tasks outlined in Section 4.0, the Field Sampling Plan.

3.1 INITIAL EVALUATION

This subsection contains the results of the environmental investigation conducted to date at the Melville North Landfill site. The Initial Evaluation summarizes the TRC presentation of the previous data collected, current risk perception, and preliminary remedial measures to be evaluated. See Figure 4-1 for Phase I sample locations referred to in Section 3.1.1.

3.1.1 Types and Volumes of Waste Present

Soil Assessment

Volatile organic compounds (VOCs), base neutral/acid extractable compounds (BNAs), pesticides, polychlorinated biphenols (PCBs), and inorganics were all detected in on-site soils.

Significant VOC contamination (greater than 1 part per million (ppm) total VOCs) was detected in subsurface soils in the central portion of the site in the suspected area of former lagoons, and in the southern portion of the site in the vicinity of MW-4. Soil samples collected in the former lagoon area and from the MW-4 location generally exhibited strong petroleum odors and/or visible oil contamination.

BNAs were detected at elevated levels (greater than 10 ppm total BNAs) in the northwest, central, and southern portions of the site.

Pesticides were detected at low levels (10s of parts per billion (ppb)) in surface soil samples across the site, with higher levels (100s of ppb) detected in the central portion of the site.

PCBs were detected in surface and subsurface soils. PCBs were detected above the 1 ppm RIDEM PCB soil action level in surface soils in the northwestern and northeastern portions of the site, and in subsurface soils in the central and southern portions of the site.

Inorganics were detected in soil samples collected from the northeastern corner of the site to just south of the site access road at levels exceeding background levels. The highest concentrations of inorganics were detected in subsurface soils generally collected at or below the water table from the north-central and central and southern central portions of the site.

Groundwater Assessment

VOC, BNAs, pesticides, PCBs and inorganics were all detected in groundwater samples collected from the site.

VOC detections at concentrations exceeding groundwater action levels consisted mostly of petroleum-related VOCs (xylene, benzene) and were limited to wells located in the central (MW-3) and southern (MW-4) portions of the site. VOCs were also detected in soil boring samples collected at the depth of the water table from the central and southern portions of the site, and signs of petroleum-related contamination (odors, oil) were observed during the drilling and sampling of these borings.

Separate phase oil was identified in well MW-3.

One BNA compound was detected above groundwater action levels in a well (MW-4) in the southern portion of the site.

A pesticide, gamma-BHC, was detected in groundwater at well MW-4.

A PCB concentration of 40 ppb was also detected in well MW-4 (PCBs were detected in the soil from this well boring). PCBs were also detected at 0.13 ppb, less than the Maximum Contaminant Level (MCL), in MW-3 in the central portion of the site.

While concentrations of inorganics exceeded groundwater action levels in most wells, the highest levels of inorganic analytes were detected in groundwater in the central to north-central portions of the site.

Sediment Sample Assessment

The sediment samples were collected from the wetland area at the northern edge of the site.

VOCs, BNAs, pesticides, and inorganics were detected in sediment samples.

The maximum total VOC concentration detected in the sediment was 11 ppb. The maximum total BNA concentration detected was 5.43 ppm. Total carcinogenic polynuclear aromatic hydrocarbon (PAH) levels in two samples exceeded 1 ppm.

Pesticides were detected in each of the sediment samples, with 4,4'-DDE detected at each location at concentrations ranging from 7.9 to 470.0 ppb.

Inorganic analytes were detected at elevated concentrations at each sample location, although different analytes exceeded background at each location.

3.1.2 Contaminant Fate and Transport

Potential routes of migration, contaminant persistence and distribution, and observed contaminant migration were considered in evaluating the fate and transport of the identified site contaminants.

Potential migration pathways for the Melville North Landfill site include the following:

- Migration of surface soil contaminants directly via surface runoff, windblown dust, or tracking (tires, shoes, etc.);
- Migration of surface soil contaminants indirectly via precipitation, leaching, and subsequent groundwater migration via volatilization to ambient air, or via uptake by plants or animals and subsequent human consumption;
- Migration of subsurface soil contaminants via precipitation, leaching, and subsequent groundwater migration; and
- Migration of groundwater contaminants via groundwater flow.

Groundwater is not used as a drinking water source on or downgradient of the Landfill. The groundwater flow direction at this site is to the west, toward Narragansett Bay. The primary migration pathway for VOCs is likely to be through groundwater. For BNAs, which are generally persistent in the environment, contamination appears to be greatest in the surface and subsurface soils, with migration to groundwater considered a potential migration route. Migration of carcinogenic PAHs to

surface water is a potential migration route in the northern, swampy area. Pesticides and PCBs were both detected in surface and subsurface soil. PCBs were detected in groundwater samples, suggesting potential migration in the groundwater (low flow groundwater sampling during this phase of the study to allow for differentiation between fluid and particulate transport). Inorganics were detected at elevated levels in surface and subsurface soils and groundwater samples, although evaluation of groundwater samples does not indicate a trend of inorganics migrating off site.

3.1.3 Preliminary Human Health Assessment

The exposure scenarios considered in the TRC Phase I risk evaluation of the Melville North Landfill site included a trespassing/current use scenario, a construction/future use scenario, an industrial/future use scenario, and a residential/future use scenario. (Note: The residential scenario is considered inappropriate but has been included here to provide historical perspective regarding previous work. Refer to Section 7.0 of this Work Plan for an explanation of the exposure scenario that will be evaluated.) The TRC developed cancer risk (carcinogenic) and hazard risk (non-carcinogenic) estimates associated with each scenario evaluated and the exposure pathway(s) driving the calculated risks are summarized below:

- Trespassing Scenario (Scenario 1) - Total cancer risk range and total hazard index ratio range are within target values.

- Construction Scenario (Scenario 2) - The total cancer risk range and the mean hazard index ratio are within target values. The maximum hazard index ratio exceeded the target value.

- Commercial/Industrial Use Scenario (Scenario 3) - The total cancer risk range and the hazard index ratio range exceed target values.

- Residential Use Scenario (Scenario 4) - The total cancer risk range and the hazard index ratio range exceed target values for both children and adult receptors.

For Scenarios 1 and 2, the major contributing factor to the calculation of cancer risk is ingestion of arsenic and carcinogenic PAHs in soil. The pathway of primary concern associated with Scenarios 3 and 4 with respect to cancer risk is ingestion of groundwater containing chlorinated VOCs (1,1-dichloroethene, vinyl chloride, and trichloroethene, which are completely based on qualified data) and inorganics (arsenic, beryllium). Ingestion of arsenic and PAHs in soil and inhalation of VOCs also are important exposure pathways in the residential use scenario with respect to cancer risks.

The primary contributor to the total hazard index ratio for Scenarios 1 and 2 is ingestion of inorganics (antimony, copper) in soil. Ingestion of inorganics (mercury, thallium) in groundwater drove the total hazard index ratio for scenarios 3 and 4. Other pathways of concern (specifically applicable to exposure of children in the residential use scenario) are ingestion of chemicals in soil and inhalation of vapor phase VOCs.

3.2 WORK PLAN RATIONALE

The Work Plan Rationale describes work plan objectives, data gaps, data quality objectives, and task rationale. The Phase II Work Plan was developed to ensure that the field investigations meet objectives described in EPA's RI/FS guidance, including:

- Define the nature and extent of contamination (waste types, concentrations, distributions).
- Provide a basis for the evaluation of contaminant fate and transport mechanisms.
- Update Phase I Human Health Risk Assessment.
- Perform an Ecological Risk Assessment.
- Update Phase I identification of federal/state contaminant- and location-specific ARARs.
- Provide a data base sufficient to support the detailed evaluation of remedial alternatives within a Feasibility Study.

In developing the Work Plan, the approach was to:

- Identify data gaps in the Phase I RI;
- Identify data quality objectives (DQOs);
- Identify types of actions that may be appropriate for addressing site problems and define associated data requirements for the technical evaluation of the actions' applicability;

- Identify interim remedial measures, where appropriate, to mitigate potential threats or prevent further environmental degradation;

- Identify optimal sequence of site actions and site activities; and

- Identify procedures that may be used to streamline the RI/FS.

3.2.1 Data Gaps

The Phase I RI provided an initial evaluation of the presence, nature, and extent of contamination at the Melville North Landfill site. Surface soils, subsurface soils or fill, sediment, and groundwater were sampled and initially characterized at the site. Geologic and hydrogeologic characteristics of the site were also investigated. A Human Health Risk Assessment was performed for the site on the basis of the Phase I RI results. However, the site was not "fully characterized" by the Phase I investigation activities. Based upon a review of all existing data and regulatory review comments, the following data gaps or issues were identified as requiring further investigation (site activities planned to address these data gaps are noted in parenthesis after each item):

- Background soil and groundwater quality (off-site surface soil samples and upgradient monitoring wells).

- Extent of Phase I-detected surface soil contamination (surface soil samples).

- Extent of landfill and site (surface soil samples and soil borings).

- Characteristics of fill materials and subsurface soils (surface soil samples and soil borings).

- Site bedrock topography (soil borings and geophysics).

- Groundwater quality in overburden aquifer and, if present, in shallow bedrock aquifer (nested monitoring well sampling).

- Extent of Phase I-detected groundwater contamination (soil gas and monitoring wells).

- Overall site surface soil quality (surface soil samples).

Four sample locations originally proposed by TRC (FRC designations: SS22, SS23, SS25, and B17) were reevaluated and removed by HNUS. Surface soil samples SS22, SS23, and SS25 have been deleted because these areas have been remediated by a Navy interim surface soil removal action. TRC boring B17 has been deleted because the location shown is in a wetland. HNUS believes that boring B18 (now numbered B17) will be sufficient to categorize this area of the landfill. Specific sample location rationale for remaining samples, which was developed by TRC and presented in their Draft RI/FS Work Plan, is presented below:

SURFACE SOIL

SAMPLE NUMBER	LOCATION/RATIONALE
SS-16	Further characterize surface soil quality at the southern end (boundary) of Site 02.
SS-17	Determine background surface soil quality for Site 02.
SS-18	Determine background surface soil quality for Site 02.
SS-19	Determine extent of PCB contamination of surface soils in the northern end of Site 02.
SS-22 (formerly SS-24)	Determine extent of PCB contamination of surface soils in the northern end of Site 02.
SS-23 (formerly SS-27)	Further characterize surface soil quality in the north central (former waste pile area) portion of Site 02.
SS-24 (formerly SS-26)	Further characterize surface soil quality in the north central (former waste pile area) portion of Site 02.
SS-25 (formerly SS-28)	Further characterize surface soil quality along the western edge of Site 02.
SS-26 (formerly SS-29)	Further characterize surface soil quality along the western edge of Site 02.

SEDIMENT

SAMPLE NUMBER	LOCATION/RATIONALE
SD-11	Proposed location - SD8 station. Determine final location based upon field observations (see Section 4.2.7.1 for sample location criteria). Purpose is to characterize the nature and extent of contamination in the site wetland area.
SD-12	Proposed location - SD9 station. Determine final location based upon field observations (see Section 4.2.7.1 for sample location criteria). Purpose is to characterize the nature and extent of contamination in the site wetland area.
SD-13	Proposed location - SD10 station. Determine final location based upon field observations (see Section 4.2.7.1 for sample location criteria). Purpose is to characterize the nature and extent of contamination in the site wetland area.

BORING NUMBER	LOCATION/RATIONALE
B-14	Determine the extent of PCB contamination in soil at the northern end of Site 02.
B-15	Determine the extent of PCB contamination in soil at the northern end of Site 02.
B-16	Determine the extent of PCB contamination in soil at the northern end of Site 02.
B-17	Determine the extent of PCB contamination in soil at the northern end of Site 02.
B-18	Characterize subsurface soil/fill quality in the north central portion of Site 02.
B-19	Characterize subsurface soil/fill quality in the north central portion of Site 02.

B-20	Determine the extent of soil contamination in the central portion of Site 02.
B-21	Determine the extent of soil contamination in the central portion of Site 02.
B-22	Determine the extent of soil contamination in the central portion of Site 02.
B-23	Determine the extent of soil contamination in the south central portion of Site 02. Actual determination of location will be made after a review of the soil gas survey data.
B-24	Determine the extent of soil contamination in the south central portion of Site 02. Actual determination of location will be made after a review of the soil gas survey data.

WELL NUMBER	LOCATION/RATIONALE
MW-5R	Investigate bedrock groundwater quality upgradient of the northern portion of Site 02.
MW-6S/R	Investigate groundwater quality upgadient of the southern portion of Site 02.
MW-7S	Investigate groundwater quality at the northern end of Site 02.
MW-8S	Further investigate groundwater quality in the north central portion of Site 02.
MW-9S	Investigate groundwater quality upgradient of the north central portion of Site 02.
MW-10S/R	Investigate groundwater quality, at the edge of the site, downgradient of contamination detected in the central portion of Site 02 during the Phase I investigation.

WELL NUMBER (Cont.)	LOCATION/RATIONALE
MW-11S	Investigate groundwater quality in the vicinity of contamination detected during the Phase I investigation at B-9. Actual determination of location will be made after a review of the soil gas survey data.
MW-12S	Further investigate groundwater contamination detected in monitoring well MS-4 during the Phase I investigation. Actual determination of location will be made after a review of the soil gas survey data.
MW-13S/R	Further investigate groundwater contamination detected in monitoring well MS-4 during the Phase I investigation. Actual determination of location will be made after a review of the soil gas survey data.
MW-14S	Investigate ground water quality at the southern end of Site 02.

Additional site characterization activities at the site include the collection of samples for media treatability information (grain size analysis, TOC, etc.).

3.2.2 Data Quality Objectives (DQOs)

The development of data quality objectives for this site investigation involves the following:

- Specifying the decision-making process and identifying why new data are needed based on the identification of data users, evaluating existing data, developing conceptual site models, and the specifying of data quality objectives for the project;
- Identifying data uses or needs to ensure adequate data are developed; and
- Specifying methods by which data of acceptable quality and quantity will be obtained.

Project objectives include the further characterization of the site with respect to the nature and extent of contamination, the chemical and physical characteristics of the site, the site contaminant fate and transport concerns, the human health and ecological risks, and the application of potential remedial alternatives.

The Phase II RI/FS Work Plan has been developed in accordance with the following data quality objectives. The data developed during the Phase II RI will need to be of sufficient quality to support the activities involved in meeting the project objectives (i.e. data evaluation, risk assessment, treatability study, and feasibility study activities). The U.S. EPA guidance provided in "Data Quality Objectives for the Remedial Response Activities" (U.S. EPA, March 1987) was issued to determine the analytical levels required to support site characterization activities. The Navy document entitled: Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program (6/88) adopted three of five data quality levels defined by EPA and designated them Levels C,D, and E. The data quality objective levels to be utilized for this investigation include:

Level I - screening - organic vapor detection using field instruments for soil gas surveys and health and safety monitoring;

Level II - field analysis for soil gas surveys;

Level C - engineering (laboratory analyses other than EPA CLP, such as physical soil tests);

Level D - Confirmation (such as TCL, TASL, including data validation); and

Level E - Non-standard (including analysis for non-conventional parameters such as TOC, BOD, TPH, and modified CLP methods).

The combined use of these data quality objective levels will satisfy the data requirements of site characterization, risk assessment, and feasibility study activities.

3.2.3 Sequenced Site Actions/Activities

The Phase II Remedial Investigation described in the Work Plan will be conducted in a staged approach in which sampling and analyses are sequenced to direct and optimize subsequent field activities. Geophysical and soil gas surveys will be used to further evaluate potential locations for the placement of borings and monitoring wells. Surface and subsurface soil samples will be collected to define the nature and extent of soil and fill contamination. Groundwater samples will be collected and analyzed to define the horizontal and vertical extent of groundwater contamination. Other field activities to be accomplished as part of the Phase II RI include preliminary aquifer characterization (slug) testing and supplemental geologic characterization. A summary of the field investigation activities planned for the Phase II RI at the Melville North Landfill are as follows:

- Geophysical Survey (seismic refraction)
- Soil Gas Surveys (portable gas chromatograph)
- Surface Soil Sampling
- Test Borings
- Monitoring Well Installation
- Groundwater Sampling
- Hydraulic Well Testing

3.3 STREAMLINING OF PHASE II - RI/FS ACTIVITIES

The results of the Phase I RI and background data indicated that additional field investigations are needed to fill in the data gaps, further address Phase I investigation finding, and address regulatory requirements documented in review comments. To streamline Phase II RI/Fs activities, existing data has been evaluated to determine if interim actions can be taken at the site. These activities include the collection of analytical data during the Phase II RI, which will aid in the evaluation of remedial technologies, and the planned interactive process for identifying potential treatability study needs and conducting treatability studies, as described in Section 9.0 of this Work Plan. The project planning for Phase II has developed a cost-effective approach that will ensure that adequate data are available to develop defensible Feasibility Study and Human Health and Ecological Risk Assessments.

Streamlining the RI/FS approach for the Melville North Landfill site recognizes that removal of all uncertainties is usually not feasible and focuses instead on collecting sufficient data to characterize the site to support site remedy selections. Sufficient data must be collected during the Phase II RI to either support a "no action" finding or allow the Navy to proceed toward the ultimate goal of site clean-up.

4.0 FIELD SAMPLING PLAN (FSP)

The FSP was prepared to support field sampling activities associated with Contract Task Order (CTO) 172, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-86-C-1282. The FSP provides the field sampling team with the direction necessary to meet the Phase II RI/FS sampling program objectives. The sampling program presented in this plan focuses on assessing the nature and extent of environmental contamination at the Melville North Landfill located at the Naval Education and Training Center (NETC) in Newport, Rhode Island. The following sections summarize the task objectives, guidelines, and procedures for the proposed field tasks to be conducted during Phase II of the Melville North Landfill Site RI/FS.

Deviations from this FSP must be approved by the Navy Remedial Project Manager (RPM), the NETC Environmental Engineer, and the Halliburton NUS Project Manager.

4.1 SAMPLING OBJECTIVES

The Phase I Remedial Investigation provided an initial evaluation of the presence, nature, and extent of contamination at the Melville North Landfill site. Surface soils, subsurface soils or fill, sediment, and groundwater were sampled and initially characterized the site. However, the site was not "fully characterized" by those investigation activities. The Phase II site investigation is being conducted to address areas of concern discovered under the Phase I investigation and any site investigation data gaps. The major objectives of this site investigation are to further assess the nature, extent, and distribution of contaminants within the soils, sediment, and groundwater; identify and characterize potential source(s) of contamination, potential contaminant migration pathways, potential contaminant receptors, and associated exposure pathways; and further investigate the extent of the landfill, characteristics of fill materials and subsurface soils, and the bedrock topography beneath the landfill.

4.2 TASK 0300 - FIELD INVESTIGATION ACTIVITIES

Soil gas surveying, seismic surveying, surface soil sampling, subsurface soil sampling, sediment sampling, monitoring well installations, groundwater sampling, and a wetlands evaluation will be conducted in support of the major objectives. Specific activities to be conducted during the investigation are presented by task in the following paragraphs. Summary tables of sample analyses, sample containers, preservatives, holding time requirements, and field quality controls for all sampling activities are presented in Tables 4-1, 4-2, and 4-3, respectively. All samples will be collected and analyses performed in accordance with EPA Contract Laboratory Program (CLP) Standard Methods and

Naval Energy and Environmental Support Activity (NEESA) guidance for Level D quality control criteria. All field activities will be conducted in accordance with health and safety procedures established in the Health and Safety Plan (HASP), which is presented as Appendix A of this Work Plan.

4.2.1 Subtask 0301 - Mobilization/Demobilization Activities

This section describes the mobilization of both HNUS personnel and HNUS subcontractor personnel.

4.2.1.1 HNUS Mobilization/Demobilization

A field team orientation meeting will be held prior to the initiation of the first field event to familiarize personnel with the scope of the field activities, and to review Health and Safety, and QA/QC concerns. Prior to the initiation of fieldwork all field team members will review the Statement of Work (SOW), the Work Plan, this FSP, the HASP, and pertinent Standard Operating Procedures (SOPs) identified in Section 4.4 of this FSP.

Equipment mobilization may include, but will not be limited to, the transport and set-up of the following equipment:

- Field office equipment
- Utility hook-ups
- Sanitary facilities
- Dumpster for trash removal
- Sampling and shipping equipment
- Hydrogeologic monitoring equipment
- Health and safety equipment
- Decontamination equipment
- Subcontractor equipment (drilling, surveying)

The Field Operations Leader (FOL), or designee of the project manager, will coordinate the mobilization of the field office, sanitary facilities, and a utility hook-up with vendors prior to arriving on-site. The Site Supervisor or designee will coordinate the location of the field trailer, sanitary facilities, and the installation of electric utilities. Equipment, materials, and work vehicles required for the field tasks will be mobilized prior to the initiation of field work, and as needed, for each specific field activity. The Site Supervisor will also coordinate any necessary equipment purchases needed to conduct the field investigation. The location for the decontamination pad will be determined during the mobilization

effort. The actual construction of the pad will occur subsequent to drilling contractor selection and prior to drilling activities.

The field equipment will be demobilized, as needed, for each sampling activity. Following completion of all field investigation activities, the field office, sanitary facilities, and electric utilities will be disconnected and removed from the site under the supervision of the Site Supervisor or designee. It is assumed that Mob/Demob activities will be conducted over a three-week period at the beginning of the field investigation program and over a one-week period at the end of the field program.

4.2.1.2 Subcontractor Mobilization/Demobilization

Subcontractors will be used for several field investigation activities: 1) laboratory services, 2) a soil gas survey, 3) a geophysical survey, 4) drilling, and 5) a topographic survey. Once the procurement process has been completed the HNUS Program Management Office will initiate the mobilization efforts by issuing a "Notice to Proceed" to the selected subcontractors for each service.

The subcontractors will be responsible for scheduling and mobilizing/demobilizing all necessary personnel and equipment in order to perform the work outlined in their respective contracts.

4.2.1.3 Property Access/Digsafe

The Navy will be responsible for obtaining access to each of the on-site and off-site locations from the respective property owners before any RI field activities are initiated. As part of the access, the Navy will inquire about the possible existence of underground utilities and structures. Verification of access and identification of unknown underground utilities and structures must be provided to HNUS before field work can begin. The Navy's NETC Public Works group will be responsible for identifying any Navy underground utilities on site prior to the initiation of subsurface drilling and/or sampling activities. In addition, the soil gas and drilling subcontractors will be responsible for contacting the commercial "Call Before You Dig" services and any other potentially effect utilities for each subsurface drilling and/or sampling location.

4.2.2 Subtask 0302 - Soil Gas Survey

In general, soil gas sampling will be used at the site to aid in defining the presence, nature, and/or extent of subsurface VOC contamination. Increased concentrations of gaseous VOCs are commonly present within pore spaces of VOC-contaminated unsaturated soils, above contaminated buried wastes, and above contaminant plumes of ground water. Analysis of soil gas is an effective screening method

to assess the presence and extent of an area contaminated with VOCs. The soil gas survey information is intended to aid in directing surface and subsurface investigation activities in the vicinity of MW-3 and MW-4 at the site. Figure 4-3 depicts proposed soil gas locations.

The results of the soil gas survey may be used to "fine tune" planned sampling locations. Significant deviations from this plan resulting from the soil gas survey findings will be discussed with representatives of the Navy and RIDEM prior to implementation of any such modifications.

4.2.2.1 Technical Approach

The results of the Phase I RI indicate two primary areas of subsurface soil VOC contamination around monitoring wells MW-3 and MW-4. A total of 15 soil gas sampling points will be established around each of these wells. A series of soil gas points (approximately 5 to 7) will be established within a 10-foot radius of each well. The remainder of soil gas points (approximately 8 to 10) will be located within a 25-foot radius of each well. (Note: It may not be possible to position a radial series of soil gas points around MW-4 based upon observations made during a reconnaissance survey conducted by HNUS on June 8, 1994.) If site conditions preclude establishment of the radial series, approximately 5 to 7 points will be arranged in an arc on the accessible sides of each well. Should it be deemed necessary by the HNUS Site Supervisor, up to 10 additional survey points may be added to further delineate areas of elevated concentrations of soil gas in the vicinity of MW-3 and/or MW-4. Any areas of staining or vegetative stress encountered during the soil gas survey will be noted in a field notebook and located on a site map.

4.2.2.2 Soil Gas Sampling Procedures

The soil gas survey will be conducted with a truck-mounted hydraulic sampling device (e.g., geoprobe). Thirty soil gas samples and associated QA/QC samples will be collected from 30 locations (one soil gas sample per location). Up to 10 additional sample locations will be added based upon review of field-generated soil gas results. The rods will be driven by the hydraulic sampling device to a depth of 3 feet below ground surface at each location. (The 3 foot sample depth was chosen because it is below the zone of organic decomposition and above the water table.) The sampling zone will be isolated from the steel pipe annulus by packing material or an inflatable packer located just above the perforations at the base of the probe. Each soil gas sample will be collected from the prescribed depth through the probe after a vacuum pump has extracted three rod/tubing volumes of gas from the probe. The soil gas sample will then be collected from the air mass by either a in-line sample collection method or by inserting a glass, gas-tight syringe into the polyethylene tubing that connects the probe to the vacuum

pump. Samples will be stored in the gas tight syringes, or if in-line sampling is employed, in air tight teflon lined septum sealed bottles pending analysis.

4.2.2.3 Soil Gas Analysis

The soil gas samples will be analyzed as soon as possible after sampling and no later than the beginning of the next sampling day. Analysis will be performed on a "laboratory grade" gas chromatograph (GC) (e.g., Hewlett Packard 5890 or equivalent) located on site and equipped with a flame-ionization detector (FID). All soil gas samples will be analyzed for BTEX compounds using modified (for soil gas) EPA Method 602 procedures. Soil gas samples will also be run simultaneously through an electron capture detector (ECD) for chlorinated compounds typically contained in industrial solvents, following modified (for soil gas) EPA Method 601 procedures. Between all sample injections (including unknowns), the syringe will be heated to 60°C and flushed with UPC grade nitrogen. Standards will be analyzed to quantify the above mentioned target compounds (to a reporting limit of 1.0 ug/l). A total FID volatiles compound concentration will also be calculated for each soil gas sample run.

4.2.2.4 Analytical Quality Control

The GC will be calibrated with, at a minimum, three standards of differing concentration, one of which will be at or near the reporting limit of 1.0 microgram per liter (ug/L). The instrument calibration curve shall be determined by linear regression of the standards with a minimum correlation coefficient of 0.99 for each of the VOCs in the standard. Once the GC has been calibrated in this manner, another calibration is not required unless a check standard demonstrates the system is out of control. Check standards will be run at the beginning of each analytical day, at intervals of every 10 soil gas samples, and at the end of the analytical day. The system is considered out of control if the check standards do not agree within $\pm$ 20 percent of their true concentration calculated from the calibration curve.

Instrument blank samples will be analyzed after each check standard or calibration curve to demonstrate system cleanliness.

Field blank samples will be collected by drawing prepurified nitrogen or ambient air (filtered through an MSA organic cartridge filter) through the sampling apparatus and probes prior to each day's sampling activities, after every twentieth sample, and at the conclusion of each day. Blank samples should not contain any VOCs above the reporting limit. If contamination is noted, the source of contamination must be identified and removed from the sampling train before sampling activities can

continue. Field blank samples are labeled and analyzed in the same manner as the actual field samples and are visually indistinguishable from the actual field samples (i.e., blind to analyst).

Duplicate soil samples shall be collected at an interval of one per ten soil gas samples. Concentrations of the VOCs found must agree within a 25 percent difference. A re-analysis is required if the concentrations found do not agree with the required range.

Prior to each use all downhole equipment (drive rods, drive points, end caps) shall be decontaminated by the subcontractor with Alconox detergent wash, followed by a distilled water rinse. After the decontamination steps have been completed, the equipment shall be allowed to drain and air dry on clean aluminum foil at a location not to be affected by exhaust fumes from vehicles or generators.

4.2.2.5 Sample Designation

For each soil gas sample collected, the soil gas grid number, depth, and ambient air temperature (at the time of collection) will be recorded in the field logbook.

4.2.3 Subtask 0303 - Geophysical Survey

The geophysical surveys will be conducted at the site to aid in determining landfill boundaries (lateral extent of fill/waste areas) and subsurface characteristics/data (bedrock depth and topography) of the geologic stratigraphy. Proposed seismic refraction lines are depicted on Figure 4-3. A perimeter survey has been chosen as the most cost effective method of determining the extent of fill material. No lines will be surveyed across the landfill given the seismic signal attenuation problems associated with landfill materials. The results of the geophysical surveys may be used to "fine-tune" planned soil boring and/or monitoring well locations. The seismic refraction geophysical survey techniques will be used in the planned investigation of the site.

Should analyses of geophysical data reveal the need for significant deviations from this plan, the geophysical survey results and proposed work plan modifications will be presented to the Navy and RIDEM for approval prior to the implementation of modifications.

4.2.3.1 Technical Approach

A seismic refraction survey is a means of determining the depths to and thickness of refracting horizons (usually overburden materials in New England) overlying a high-velocity refracting horizon (usually bedrock or till). The seismic velocities measures by this technique can be used to calculate

the mechanical properties of subsurface materials (moduli values), as well as for material identification and stratigraphic delineation and correlation (with stratigraphic data collected from intrusive technologies such as geologic logging of soil borings).

Interpretations of the strata's geometry are made from travel time curves showing the measurement of the time required for a compressional seismic wave to travel from the source ("shot") point to each group of vibration sensitive devices (seismometers or geophones). Various seismic sources may be used to create the compressional wave, including a drop weight, an air gun, and small explosive charges. The geophones are located at known intervals along the ground surface. The geophone spacing is dependent on the desired depth of investigation and the estimated seismic velocities of the overburden and rock units believed to be beneath the study area.

4.2.3.2 Procedures

As stated above, the proposed seismic refraction lines are depicted in Figure 4-3. The actual project specifications and survey line locations for the seismic refraction survey at the site will be determined during a pre-investigation site visit with geophysical subcontractors.

4.2.4 Subtask 0304 - Ecological Field Evaluations

A on-shore ecological characterization of the site will be performed as described in this subsection. This characterization will involve the following tasks:

- identify the types and spatial extent of habitats that are present on and around the site;
- identify the species and biological communities that may use these habitats and that may be potential receptors with regard to contaminants present in soils, sediments, and surface waters at the site;
- determine, through direct observation, the general functional condition of wetlands on the site;
- determine the extent and nature of contamination of environmental media with regard to potential exposure of receptor species;
- identify on-site and adjacent wetlands and their boundaries; provide maps of the wetland boundaries relative to the site; assess the functional value of the identified

wetlands based on standard methods; contribute to the habitat descriptions of the site and nearby areas.

4.2.4.1 Characterization of Habitats

The objective of the habitat characterization is to identify the nature and composition of non-marine animal and plant communities in the vicinity of the site to provide a basis for identifying potential receptors. Section 8.3 of this plan outlines the approach that will be used to evaluate on-site wetland systems. The marine ecosystems near the site will be characterized in a separate study.

To characterize the habitats at and in the vicinity of the site, biologists will provide: descriptions of the nature and composition of plant and animal communities at the site and its immediate vicinity of the site; descriptions emphasizing wildlife species, their habitat, and key food organisms; selection of species or groups of species for evaluation of potential risks or impacts; a description of significant habitat; and, if applicable, information on federal or state threatened or endangered species.

These tasks will be accomplished by conducting a literature search; a review of threatened and endangered species; a field assessment (a qualitative survey of the flora and fauna); and a stressed vegetation analysis.

4.2.4.2 Literature Review

The purpose of the literature review is to provide background information on the species of plants and animals expected to occur on the site and in proximate areas; the use of the general area by migrating or overwintering species; and the general distribution and abundance of species in the area. The review will include an examination of data bases as well as files at RIDEM and the agencies listed in Subsection 8.5.1 - Literature Review. The primary literature will be consulted for pertinent information.

4.2.4.3 Review of Threatened And Endangered Species

RIDEM and US Fish and Wildlife Service, Office of Endangered Species, lists will be reviewed by HNUS to identify endangered, protected or threatened species that may inhabit or use the Newport area and the environments associated with the base. This information will be checked with RIDEM and the US Fish and Wildlife Service, and maps will be provided at appropriate scales to show important habitat or nesting sites for these species. If appropriate, these maps will be presented at the same scale and on the same base map as the wetland delineations. The determination of potential effects on any

endangered or threatened species identified as being present in the site area will receive special consideration.

4.2.4.4 Field Assessments

The purpose of this task is to provide qualitative field verification of the types of habitat and wildlife on and near the site.

The goal of the wildlife assessment is to provide site specific observations concerning the diversity (i.e. number and type) of species rather than data for assessment of population structure or community analyses. Since the objective is to provide an inventory of terrestrial fauna on site, the survey will be qualitative rather than quantitative. These data will be used to provide an informed site-specific basis for selection of ecological components (receptors) for the Ecological Assessment.

Field biologists will also conduct field assessments of the various terrestrial wetland and aquatic habitat types on site and in nearby areas. The assessments will require coordination with the team of wetland specialists conducting the wetland delineations. One or more of the wetlands specialists will also perform field assessments.

The survey requires a walkover of the site. Positioning will be by "line of site" and will therefore be approximate. A field map will be used to guide the survey and for recording observations. The walkover path will be planned and modified as appropriate in the field. The path will be dictated by the types of environments encountered and their extent, as based upon visual observations. Obvious habitat features that may be of particular value to wildlife will be examined closely. The course of the walkover will be based on such observations as nesting sites, physical signs of wildlife, audible signs of birds, changes in vegetation patterns, obvious changes in hydrologic conditions, changes in slope, and physical accessibility.

During the survey, observations will be made on:

- major flora in wetland and upland areas;
- bird, amphibian, and mammal sightings or physical evidence of these (e.g., nesting sites, tracks); and
- the presence/absence of soil invertebrates by qualitative sampling (digging and sieving on site);

Observations will be recorded in several ways:

- a base map will be used to mark the locations of major habitat types; and
- observations and notes will be recorded by the biologist in a field log book.

Lists of flora and fauna will be produced for inclusion in the report. These lists will be species-specific where possible. The method for species identification (i.e. visual sighting, identification by tracks or other physical evidence, and audible identification) will be included on the fauna list. The characterization of site flora will be initiated during this step, and will be supplemented during the wetland delineation and functional assessment.

4.2.4.5 On-site Stressed Vegetation Analysis

During the survey, observations will be made on the occurrence of stressed vegetation, which can be caused by the presence of toxic substances at the site. Possible indicators of stressed vegetation include: discoloration, low (relative to expected) population density, monospecific stands, low species diversity, invasion of opportunistic species, and abundance of species indicative of "primary succession". Such conditions may not always indicate toxic effects, given that substrate, hydrologic, meteorologic, and physical disturbances may also cause such symptoms. Therefore, stressed vegetation data must be interpreted cautiously.

If the Flora and/or Fauna of a site area appears to be "stressed", the species composition and distribution will be qualitatively evaluated and recorded. The size of the area will be measured and recorded. The physical characteristics of the area will also be recorded including: observations of the relative elevation; the soil types at depths of up to 18 inches below ground surface; exposure to tidal and wave actions, and the presence or absence of water.

If encountered, areas of stressed vegetation will be recorded on field notes, photographed or videotaped and flagged for subsequent surveying onto maps at the same scale as the wetland delineation maps (see subsection 4.2.4.6.1).

4.2.4.6 Wetland Delineation and Functional Assessment

The purpose of the wetland delineation and functional assessment is to identify on-site and adjacent wetlands and their boundaries; create maps delineating the wetland boundaries relative to the site;

assess the functional value of the identified wetlands based on standard method; contribute to the habitat descriptions of the site and nearby areas; and provide input to the exposure assessment and risk characterization.

The wetlands delineation of the Melville North Landfill Site will be conducted based upon the State and Federal Methods in accordance with R.I.G.L. Section 2-1-18 and the Federal Manual For Identifying And Delineating Jurisdictional Wetlands, 1987. The wetland functional analysis will use the Wetland Evaluation Technique (WET 2.0) model developed by the Army Waterways Experiment Station.

The wetlands delineation will establish the wetland boundary based upon the three essential characteristics of wetlands: hydrophilic vegetation, hydric soils, and wetland hydrology. The 1987 Federal Manual describes technical criteria for identification of these characteristics. The criteria for all three characteristics must be met for an area to be identified as a wetland. The State of Rhode Island uses a vegetational approach to establish the limits of a wetland. Both methods will be employed to assess whether a particular area meets either set of criteria. This is done by conducting a field survey of the plants, soils, and general hydrology of on-site and adjacent areas. The wetland scientist will augment the WET 2.0 analysis with an interpretation of results combining the vegetative, soils, and hydrologic aspects of the study.

The wetland functional assessment will evaluate three general aspects of a wetland: social significance, effectiveness of the wetland, and habitat suitability for species and species groups. The WET 2.0 model will be generated using data from the wetlands delineation field survey, and appropriate agency files, maps, and photographs.

4.2.4.6.1 Preparation for Wetlands Delineation And Functional Assessment

In preparing the Wetlands Delineation, wetland specialists will review various maps and surveys, as available. These will include: aerial photographs, U.S. Fish and Wildlife Service (USFWS) Wetland Inventory maps, United States Soils Conservation Service soil survey maps, Rhode Island State wetland and Coastal Resource maps, United States Geological Survey maps, and Site maps compiled by previous and current consulting companies.

In preparing for the Functional Analysis, the data sources that will be generated and reviewed include:

- Maps and surveys as specified above for the wetland delineation;
- The assessment area size indicated on a site map;

- The input zone ("area surrounding the assessment area that may have significant impact on the assessment area in terms of sediments, nutrients, or contaminant input"), which will be identified on a map;

- The watershed which will be delineated on a topographic map;

- Service areas identified, including delineations of service area watershed ("Services are wetland functions or values that have a fairly well defined, off-site delivery point. The service area is the point to which the service is delivered." An example of a service area is a downstream reservoir that is protected by an upstream wetland that removes toxics);

- The locality of the site and region of Rhode Island will be defined (The WET Manual defines locality as a relatively small political or hydrologic area such as a township, county, section, watershed, or similar hydrologic division; region is a larger political, ecological, hydrologic, or jurisdictional area such as a state, a region, flyway, Corps District, EPA Region, or hydrologic unit that is relatively homogeneous in terms of topography and landscape pattern); and,

- Form A: Site Documentation. This form will be completed (according to the WET Manual, Form A documents general information about the wetland being evaluated; it serves as a useful reference throughout the evaluation procedure and as documentation of the evaluation following completion).

4.2.4.6.2 Wetlands Delineation Field Program

The field portion of the wetlands delineation will be performed coincident with the qualitative field assessment (see Subsection 4.2.4.4). The discrete steps that will be used to delineate wetlands are described below. The wetlands delineation will be based on the Federal Manual For Identifying And Delineating Jurisdictional Wetlands, 1987, and its amendments.

The demarkation of the delineated wetland will be accomplished by placing flags along the wetland-non-wetland boundary close enough for accurate surveying and mapping (about every 50 feet). The flags will be located by a subcontracted surveyor. Field notes will be recorded on field logs. Field notes will be transferred to approved data sheets and included in an appendix of the final report.

The field delineation of the site and off-site areas will begin at the property boundary or other convenient (easily surveyed) location. The wetland boundary will be approximated through visual observations and professional judgment exercised in the field. A transect will be established extending from within the wetland perpendicular to the approximated boundary and into the non-wetland area. A sample area (quadrant) will be established on the lower (i.e. wetland) end of the transect and observations of vegetation, soils, and hydrology will be made. These observations will document the presence of the vegetative, soil, and hydrologic criteria necessary to define a wetland. A second quadrant will be established just upgradient of the estimated wetland boundary (in the estimated non-wetland), which should allow documentation of non-wetland conditions. A third quadrant will be established on the estimated boundary. Data from these quadrants will be used to refine the location of the boundary, as needed.

Once the boundary has been determined in this way, it will be walked and flagged at approximately 50 feet intervals, using visual observations (vegetation, soils, topography, and hydrology) and professional judgment. Additional documentation transects will be established as described above when different cover types are encountered. A minimum of three documentation transects will be utilized on the site.

As part of the wetlands delineation, a map will be prepared by a local surveyor (contracted separately) and the information obtained at transect locations will be transferred to data sheets.

Appropriate keys and text to identify wetland plants and hydric soils will be used. These will include but not be limited to:

- Reed, Porter, 1988. National List Of Plant Species that occur in wetlands; Northeast (Region I);

- Fernald, Linden. Gray's Manual Of Botany;

- Tiner, Ralph W. Jr. 1988. Field Guide To Non-Tidal Wetland Identification, Maryland Department of Natural Resources, Annapolis, MD and USFWS, Newton Corner, MA; and

- County Soil Conservation Service Publications (the specific publications will depend upon information acquired during the literature review and interviews with the County Soil Service).

The specific step-by-step field activities for the wetland delineation will include the following:

1. A general reconnaissance survey of the delineation area will be completed.

2. Vegetative cover types present within the study area will be identified.

3. Starting points will be established for wetland boundary delineations.

4. A transect perpendicular to site contour will be established.

5. Wetlands will be located according to the Federal Manual For Identifying And Delineating Jurisdictional Wetlands, 1987 based on vegetation, soils, and hydrologic criteria as well as by state criteria.

6. A sampling quadrant will be established within the wetland. The quadrant will be of such a size that its center will be within 5 to 15 feet of a similar upgradient (i.e. non-wetland) quadrant across the estimated wetland boundary. The wetland hydrology, soils, and vegetation will be documented. Some of the specific observations that will be documented include: hydrology, which will be documented based on field observations such as digging a hole in a wetland area to estimate groundwater levels; squeezing soils to estimate saturation; evidence of flooding such as discolored leaf litter; and the first 18 inches of soils will be profiled by visual observations, including estimates of soil structure, texture, and horizon. Determinations whether the soils are organic; and, estimates of mineral content in soils based on color using the Munsell Soil Color Chart. The process of documenting vegetation will include identifying species in each vegetative layer, estimating floral abundance, identifying dominant species, and classifying the dominants as hydrophilic or not.

7. Work will proceed by moving upgradient along the transect to the nearest estimated upland quadrant. Non-wetland hydrology, soils, and vegetation will be documented as described in step 6.

8. Work will proceed by moving to the estimated wetland boundary and establishing an additional sampling quadrant. Conditions will be documented as described in step 6.

9. Work will proceed by flagging the wetland boundary at approximately every 50 feet. As described above, the placement of these flags will be based upon information obtained from the quadrants, visual observations such as a break in the slope of the land or changes in vegetation, and professional judgement.

10. A new transect will be established within every cover type and steps 4 through 9 will be repeated.

11. A minimum of 3 transects and at least one transect in each cover type will be established. Transect intervals should not exceed 0.5 mile as dictated by the 1987 Federal Manual.

Immediately after completion of field work, the field biologists will prepare documentation data forms that include: recording soils, vegetation, and hydrology data, and locating transects on a base map. The specific type of data is described in Step 6 above and elaborated upon in The Mandatory Technical Criteria For Wetland Identification, as described in the Federal Manual.

4.2.4.7 Sediment Sampling

Sediment sampling of the salt marsh located in the northern portion of the Melville North Landfill study area will be conducted as part of the wetlands evaluation this RI. The proposed sediment sampling program will provide additional data on the distribution of the wetland sediment contaminants identified during the Phase I RI.

Technical Approach

Three locations in the wetlands will be chosen for sediment sampling. The proposed sediment sampling locations are shown on Figure 4-4, however, if areas of visible sediment contamination and/or stressed aquatic vegetation are observed during the wetlands delineation, the actual sample locations will be chosen based on field observations.

The list of sediment samples that will be collected are presented on Table 4-6. Sediments will be collected for analysis of the parameters listed on Table 4-1. The sample container, preservative, and holding time requirements for these samples are listed on Table 4-2. Associated QC samples to be collected with the sediment samples are listed on Table 4-3.

Sampling Procedures

Hand augers will be used to obtain soil/sediment samples to a depth of 12 inches. The sample will be emptied into a stainless steel mixing bowl. The soil will be mixed to obtain a representative sample and placed into the sample bottle. A stainless steel scoop or spatula will be used to remove the sample from the auger and the mixing bowl, and then transfer the sample to the appropriate sample bottle.

Sample collection equipment shall be decontaminated prior to use and between each sample location, as specified in Section 4.6. Standard Operating Guideline SA-1.2, located in Appendix C, provides additional information on sediment sampling, including equipment and techniques.

Note that soil and sediment samples do not receive chemical preservation, however, all sediment samples will be stored and shipped on ice following sample collection.

4.2.4.8 Data Products

The data products from the habitat survey will include tables and maps that will facilitate a qualitative biological characterization of the site and proximate areas. These will be provided in a report that will include:

- Narrative descriptions of the nature and composition of plant and animal communities in the immediate vicinity of the site referencing a combination of maps (for major vegetation and habitat types) and tables (for species composition of the communities) obtained and described in Section 4.2.4.4 and 3.3;

- Descriptions emphasizing wildlife species observed as described in Section 4.2.4.4, their habitat requirements described in available literature, and key food organisms; important features of the biology of these species, such as migrations into and out of the area and reproduction obtained through pertinent literature sources;

- Selection of species or groups of species for evaluation of potential risks or impacts, based on the information gathered from available literature and the planned field survey. This list will include: terrestrial vegetation, soil invertebrate community, amphibians, reptiles, mammals, and birds, depending on the nature of the environment;

- A description of significant habitat, wetlands, regulated streams, lakes, and other resources in the immediate vicinity of the site. As suggested by US EPA (1989) guidance, we will describe habitats that "are unique or unusual or necessary for continued propagation of key species". The U.S. Fish and Wildlife Service and State Of Rhode Island Department Of Environmental Management are primary sources of this information; and

- Information on federal or state threatened or endangered species. If appropriate, maps will be provided at the appropriate scales to show the observed or historically recorded locations of habitats or nesting sites for such species.

- A wetland delineation and functional assessment report. The report will be prepared which will include a wetland map and observations necessary to substantiate professional opinions as to wetland functional values such as Ground Water Recharge, Production/Export, Ground Water Discharge, Wildlife Diversity/Abundance, Flood-flow Alteration, Aquatic Diversity/Abundance, Sediment Stabilization, Recreation, Sediment/Toxicant Retention, Uniqueness/Heritage, and Nutrient Removal/Transformation.

- A requirement that: records are extended into WET 2.0 computer program (the records are those as defined in Wetland Evaluation Technique Volume 2, Methodology, by Paul Adamus, E.J. Clairain, Jr., R.D. Smith, and R.E. Young, October 1987, Department of the Army Waterways Experiment Station); identifying key conditions which lead to a particular functional rating; correlating conclusions with professional opinions; and rectifying differences between computer output and professional opinions.

- A requirement that the functional wetlands analysis will use the WET model. The WET evaluates three aspects of wetland functions: social significance that WET defines as an assessment of the value of a wetland to society due to special designation, potential economic value, or strategic location; effectiveness and opportunity; and habitat suitability for species and species groups.

The Ecological Risk Assessment (ERA) report will use this information to support the exposure assessment and characterization of risk to help select appropriate receptors and describe the existing environment.

4.2.5 Subtask 0305 - Surface Soil Sampling Program

The objectives of the surface soil sampling are to assess the presence and nature of surface soil contamination at the site. This information will aid in meeting overall sampling plan objectives. Site area specific background surface soil samples will be collected.

4.2.5.1 Technical Approach

Surface soil samples will be collected from seven on-site locations and two off-site (background) locations. The planned locations of the surface soil samples are shown on Figure 4-4. These samples will be collected from the following general locations: around areas of documented Phase I soil contamination, surface soil areas not sampled in Phase I, and the site boundaries. Refer to Table 4-6 for a summary of soil samples. Refer to Table 4-1 for a summary of sampling analyses. The rationale for each of the planned surface soil samples is presented in Section 3.0. In the absence of visible signs of contamination, PID readings will be taken in the proposed surface soil locations prior to collection of the surface soil sample.

The two "background" surface soil samples will be collected from two locations east of the site across Defense Highway. An attempt has been made to select background soil sample locations believed to be representative of site background soil conditions and away from other potential sources of contamination (e.g., roadway, railroad tracks).

4.2.5.2 Surface Soil Sampling Procedures

Surface soil samples will be collected from two depth intervals, depending upon the sample analyses to be performed. Those samples for organic Target Compound List (with the exception of VOCs) and inorganic Target Analyte List analyses with cyanide, will be collected directed from the 0 to 12 inch depth interval, as measured below any surface vegetation (leaves, grass, rootmat). Samples will be collected with a stainless steel scoopula or trowel. Soil samples to be analyzed for VOCs will be collected from a depth of at least 6 inches but not more than one foot below the ground surface, using a stainless steel trowel or a hand bucket auger.

All soil but the sample portion designated for VOC analysis will be homogenized in a stainless steel bowl prior to being placed into appropriate laboratory containers. Roots, cobbles, and other solid material larger than 0.5 inches in diameter will be discarded. Aliquots of the resulting mix will be split into three containers. Sample containers are described on Table 4-2. A duplicate sample for CLP analysis will be collected at a 10 percent frequency. Refer to Table 4-3 for the field quality control

sample summary. Surface soil sample designations are described in Section 4.3. Samples for VOC analysis will be collected separately and transferred directed to the sample container to minimize loss of VOCs from the sample.

Stainless steel scoopulas, trowels, bowls, and other sampling devices (hand augers) will be decontaminated prior to initial use in the field, between sampling locations, and at the end of the day.

The HNUS geologist will maintain documentation of all sampling activities in a field logbook. Soil samples will be described using the Unified Soil Classification System. In addition, general descriptions (e.g., stains, odors) of each surface soil sample collected will also be documented, if applicable.

4.2.6 Subtask 0306 - Subsurface Soil Boring Program

Subsurface soil borings will be conducted to aid in assessing the presence and nature of soil contamination at the site. Proposed soil boring locations are presented on Figure 4-2. Table 4-4 presents a summary of the soil boring program. If applicable, information obtained from the geophysical and soil gas surveys will be used to "fine tune" these planned soil boring locations at the site. The soil borings are planned to further investigate the characteristics of the fill and soil at the site and the extent of subsurface soil contamination detected in Phase I. The Phase II soil boring rationale is presented in Section 3.0.

The proposed soil boring locations may be reassessed based upon any significant findings of the site geophysical and soil gas surveys. Information obtained from the soil boring activities may, in turn, be used to "fine tune" any planned monitoring well locations. In instances where soil boring results indicate an alternate location for a well (e.g., high levels of contamination observed in fill or aquifer), the soil boring may be used for installation of a ground water monitoring well. Any major deviations to the Field Sampling Plans, based upon such field observation, will be discussed with representatives of HNUS, the Navy (NORTHDIV), and RIDEM prior to implementation of such modifications.

4.2.6.1 Technical Approach

A drilling subcontractor will conduct the soil boring operation under the supervision of an HNUS field geologist/engineer. Soil borings will be completed and sampled at eleven locations across the site. The planned soil boring locations are illustrated on Figure 4-5. Soil borings will generally be drilled using a hollow-stem auger drilling technique. Boreholes will be advanced at specified locations by the

drilling subcontractor. Soil samples will be collected continuously using split-barrel samplers to the depth of competent bedrock (estimated on site to be approximately 20 feet below ground surface).

4.2.6.2 Split-Barrel Sampling Procedures

Soil samples will be collected at 2 foot intervals from each borehole into the subsurface ahead of the auger. Standard penetration tests will be conducted for every 2 foot sampling interval. The general procedures outlined in ASTM-D-1586-84 will be followed, with the exception that a 3-inch diameter split-barrel sampler and a 300 pound slide hammer will be used to maximize the probability of collecting a sufficient volume of subsurface soil to satisfy all sample volume requirements.

After each split barrel is retrieved and opened, the soil sample will be monitored for the presence of total VOC vapors with a portable flame or photoionization detector. Positive VOC detections will be recorded on the field boring logs.

Immediately after monitoring the sample for VOCs, a representative aliquot of soil will be collected by the HNUS field geologist/engineer for possible VOC analysis. This will be performed by first splitting the sample longitudinally with a decontaminated stainless steel scoopula or other device. Portions of each longitudinal section will be selected from the bottom of the sample and every 0.1 foot interval above that point. These portions will be placed directly into a 4 ounce wide-mouth-jar using the scoopula or another device. Sufficient volume of soil will be collected to ensure zero head space when the cap is placed on the jar. To the extent possible, care will be taken to ensure the soil matrix of each portion is only minimally disturbed so that an accurate soil description can be logged. After collection the sample for VOC analysis, the physical characteristics of each soil sample will be described using the Unified Soil Classification System (U.S.C.S.) on field boring logs. General observations such as staining, odors, fill material and wastes should also be included on the boring logs.

After classification, the remaining portion of the soil will be homogenized in a stainless steel mixing bowl. Representative aliquots of the 2-foot split-barrel samples will be collected by the HNUS geologist/engineer in appropriate containers for the analyses specified in Table 4-2. Not all of the collected samples will be chosen for analysis. A minimum of two soil samples will be selected from each of the soil borings for the TCL/TAL analyses, including: the 0 - 1 foot sample interval (surface soil), and the last sample interval with identifiable fill material. If no fill material are observed in a boring, the second sample will be collected from directly above the water table. In addition, if signs of potential soil contamination (oil, odors, stains) are observed below the fill material or the water table in a boring, a third sample will be collected from the deepest, 2-foot depth interval of observed contamination.

Soil borings will be backfilled to within 1 foot of the ground surface, after which a cement-bentonite grout will be used to top off the hole to minimize potential future human exposure to contaminated drill cuttings. Remaining drill cuttings will be handled as described in the Investigation Derived Waste Plan in Section 4.8 of this FSP.

4.2.6.3 Documentation

Each Field Geologist/Engineer will maintain documentation of all activities for individual drill rigs in separate logbooks. Boring logs will be maintained by the geologists/engineers for each borehole. Soil samples will be described using the Unified Soil Classification System (U.S.C.S.). The following information will also be included on the boring log prepared for the soil boring:

- Sample number and types
- Sample depths
- Blow counts
- Sample recovery/sample interval

In addition, changes in lithology depths, sample moisture, water content, PID readings, Personal Protective Equipment (PPE), drilling and sampling equipment used, plus the date, time, weather conditions, total depths, and other miscellaneous observations made during drilling shall be recorded on the boring log.

The rock core will be described, classified, and logged using standard rock description methods. The following information, when applicable, will be included in the description of rock core:

- Core run number
- Depth interval
- Rock Quality Designation (RQD)
- Core recovery (%)
- Color
- Hardness
- Lithologic/mineralogic description
- Breaks
- Depth and angles of fractures

Information about the drilling activities such as start/finish times, standby times, and problems or changes encountered during drilling will be recorded in the site logbook maintained in the field trailer.

All health and safety data, including elevated readings at individual locations, shall be recorded in the Site Safety Officers's (SSO) logbook or the site logbook. The geologists/engineers are responsible for relaying health and safety information to the Site Safety Officer (SSO) who will inform the Field Operations Leader (FOL).

The boring log will be used to prepare the daily paysheet. This report will identify drilling activity and quantities of materials used on a daily basis, and shall be signed by the drill rig foreman (or equivalent) and the field geologist/engineer. The reports will be submitted to the HNUS Project Manager and Lead Geologist at the end of each week.

The following forms are to be completed by the field/rig geologist or engineer:

- Daily Paysheet
- Field Boring Log
- Weekly Field Summary Report

A copy of the forms that will be utilized during the RI field activities are located in Appendix B of the Work Plan.

4.2.7 Monitoring Well Installation/Development

Monitoring wells will be installed to aid in assessing the nature and extent of any groundwater contamination. The monitoring wells will also be used to provide hydrogeologic information on the aquifer characteristics. The Phase II monitoring well rationale is presented in Section 3.0.

As stated earlier, information obtained from initial Phase II RI field activities (test borings, soil gas sampling, geophysical surveys) may be used to "fine tune" the final well locations at the RI site, as justified by the information. The planned well locations may be reassessed and relocated if the review of preliminary survey data indicates other more suitable location for investigating subsurface soil and groundwater contamination. Any proposed deviations to the well installation locations will be reviewed with NORTH DIV and RIDEM prior to initiating the well installation program. The proposed monitoring well locations are shown on Figure 4-6. A summary of well construction activity is presented on Table 4-4. Figures 4-7 and 4-8 provide well construction details.

4.2.7.1 Monitoring Well Installation Technical Approach

The Phase II well installation program will consist of the installation of 13 new monitoring wells, consisting of seven single overburden wells and three clusters with two wells (one overburden and one bedrock) in each cluster. Overburden wells will be constructed in accordance with the instructions presented in Section 4.2.7.2. Bedrock wells will be constructed in accordance with the instructions presented in Section 4.2.7.3.

The monitoring well drilling program will generally adhere to the following guidelines:

- Wells will be constructed of 2-inch ID Schedule 40 PVC.

- Well screen lengths will be 5 to 10 feet for monitoring wells, depending on hydrologic (depth to water) and geological (stratigraphic) conditions.

- All wells will have a locking protective casing designed and installed in a manner to prevent frost heaves from damaging well integrity (see Appendix C, SOP GH-1.7, Section 5.2.4, for construction details).

- Wells will be developed by gentle surging and pumping. If development time approaches two hours at an individual well and well development criteria have not been met (see Well Development, Section 4.2.7.6) the Site Supervisor will suspend development activities and will notify the HNUS Project Manager. The HNUS Project Manager will consult with technical advisors and recommend to NORTH DIV what course of action should be taken regarding the development of the well.

- The drilling program will be conducted in a manner that will minimize the possibility of cross-contamination of aquifers if more than one is found to exist (see Appendix C, SOP GH-1.4, Section 5.3).

Monitoring wells will be constructed of 2-inch ID, non-glued, flush-jointed, threaded, Schedule 40 PVC casing. All joints shall be fitted with an o-ring or wrapped with Teflon tape. Well screens will be equipped with a screw-in PVC end plug. A sump sediment trap shall be installed in overburden wells.

Well screens will vary from 5 to 10 feet in length depending on location-specific conditions; a screen factory slotted size of 0.010 inch shall be used. The depth of the screened interval for each well will be determined in the field by an HNUS representative based on subsurface conditions encountered.

Locks using identical keys will be supplied by the drilling subcontractor for all newly installed wells. Monitoring wells will be surveyed after installation to determine vertical and horizontal coordinates. Well construction details will be documented on a Well Construction Report form by the HNUS geologist/engineer. An example of the form is presented in Appendix B of this Work Plan.

Each well cluster will be composed of a bedrock well and a shallow overburden well. Bedrock wells will be advanced using a drive and wash drill method (or by spun casing if drive and wash cannot be employed because of site conditions) and will be screened from 10 foot to four foot depth interval below the top of bedrock. The screened interval will be terminated four feet below bedrock to allow for the placement of filter pack and bentonite seal. The screened interval of the overburden well in each cluster shall be determined in the field. Variables to be considered in establishing the final well depth will include geologic materials encountered, observed contamination, depth to the water table, and site sampling objectives. Analysis of water level data from these well pairs will provide information regarding the presence or absence of any vertical gradients in the site groundwater flow system.

4.2.7.2 Overburden Monitoring Wells

The overburden wells will be installed in boreholes advanced with hollow stem augering methods. Minimum 4 1/4-inch ID augers will be used to advance the borings to the depth of competent bedrock (estimated to be approximately 20 feet below the ground surface of the site). The only drill fluid permitted for use is potable water, to control running sands if they are encountered.

These inch O.D. split-barrel soil samples will be collected continuously at 2-foot intervals from the well borings until the bedrock or split-barrel refusal has been reached. For the two upgradient bedrock wells, below the water table split-barrel samples will be collected at 5-foot intervals.

In clustered well borings, split barrel samples will not be collected from the shallow well. The deepest well shall be advanced first and a monitoring well installed at the desired depth.

Well screen and riser lengths may vary for each well. Screen lengths for wells intercepting the water table will be a maximum of 10 feet, with no more than 5 feet extending above the water table. The 5-foot length of screen above the water table is intended to maintain the water table within the screened interval during seasonal and/or diurnal groundwater fluctuations. In the event that shallow groundwater condition (less than 8 feet below ground surface) is present at a particular location, the screened interval may be shortened at the discretion of the field geologist to permit construction of all necessary features.

Well riser lengths will be field-determined so the top of the riser extends approximately 2 feet above the ground surface for wells with stick-up protective casing, and approximately 4 to 6 inches below grade for wells with flush mounted road boxes. Refer to Figure 4-7 for complete well construction details.

4.2.7.3 Bedrock Monitoring Wells

The bedrock wells will be installed in boreholes advanced with either a spun casing or drive and wash drilling methods. Minimum 4-inch inside diameter (ID) casing will be used to advance the borings to the bedrock surface. The casing will be further advanced 6 inches into competent bedrock prior to coring the bedrock. The drilling fluid shall be purged from the boring and replaced by clean drilling fluid prior to coring. The only drill fluid permitted for use is potable water.

The boring shall be advanced 10 feet via coring using two 5-foot, double-walled, NX rock core barrels. The maximum footage of bedrock coring will be 10 feet. The recovered rock core shall be removed from the core barrel and placed in a wooden core box. The bedrock description will be recorded on the boring log by the HNUS geologist (see Section 4.2.6.3 for details).

A 6-foot PVC well screen will be installed in the bedrock annular space created by the coring and the annular space outside the screen will be backfilled with filter sand to 2 feet above the top of the well screen. A 2-foot bentonite pellet seal will be placed above the filter sand. Refer to Figure 4-8 for well construction details.

4.2.7.4 Drilling Fluids

Potable water obtained from a HNUS preapproved water supply will be used for drilling purposes. The water will be obtained from a hydrant or other source and transported in truck-mounted tanks. Random tanks of water transported to the properties will be screened for VOCs by HNUS according to procedures described in SOP SF-1.5 (see Appendix C).

4.2.7.5 Well Identification

Each well cluster shall be identified by an assigned number. To identify individual wells within a cluster, a letter will follow the well number; bedrock wells shall be designated by an "R", and the shallow overburden wells shall be designated by a "S".

4.2.7.6 Well Development

Wells will be developed by bailing and/or surging and pumping, as determined by the field geologist. Fine-grained material around the well screen will be drawn into the well and removed by agitating the well water with a surge block and simultaneously pumping water from the well at a low discharge rate. A centrifugal pump outfitted with ASTM drinking water grade polyethylene tubing will be used for removing the water from the well. To prevent cross-contamination between the wells, the surge block will be decontaminated between use in each well. The surge block will be decontaminated with non-phosphate detergent and tap water, rinsed with tap water, rinsed with methanol, air dried, and rinsed with deionized water. The polyethylene tubing will also be replaced between each well. The dedicated new tubing will be rinsed with deionized water prior to its use. Water produced during well development will be containerized in 55-gallon drums (DOT Specification 17) for characterization and analysis and will be visually checked for the presence of a sheen. If a sheen is observed, an oil/water interface probe will be used to check the appropriate well(s) for the presence of non-aqueous phase liquids (NAPLs).

Based upon field conditions, should the use of the surge block and pumping technique be deemed inappropriate by the HNUS field team an alternative method will be used to develop the well. A suitable pumping device (e.g., submersible pump, Waterra™ hand pump) will instead be placed in the well and used for development. Equipment inserted into the well for development will either be dedicated to that well, or, at a minimum, washed with non-phosphate detergent and tap water, and rinsed with tap water and then deionized water prior to each use.

The volume of ground water extracted from each monitoring well during development will be monitored and water quality parameters will be determined every 15 minutes: pH, temperature, specific conductance, and turbidity. Development will continue until pH, temperature, and specific conductance have all stabilized and turbidity is $\leq$ 10 NTUs. If the NTU criteria is not achievable, the parties will determine if a turbidity standard of + or - 10 percent of successive well volumes is appropriate on a case by case basis.

If a well is not completely developed after 2 hours, the FOL will notify the HNUS Project Manager. The HNUS Project Manager will recommend to NORTH DIV what course of action should be taken regarding the development of the well.

At the time of the development of the Phase II wells, the turbidity of the groundwater in the Phase I wells will also be checked. Phase I wells will be redeveloped, as necessary, according to the above-stated criteria, or previously accepted well-specific NTU levels. Should separate phase product be

observed on the water removed from Phase I wells during redevelopment, these wells will be checked for the presence of NAPLs with an oil/water interface probe during the groundwater sampling task prior to purging and sample collection.

4.2.8 Subtask 0308 - Groundwater Sample Collection

Monitoring wells were installed at five locations in Phase I (MW-1 through MW-5). Shallow ground water table wells were installed at each of the locations. In Phase II, a total of thirteen monitoring wells are planned to be installed at ten (nine new, and one existing) location.

The planned Phase II well locations consist of six shallow groundwater table wells, three shallow groundwater table wells paired with bedrock wells, and one bedrock well paired with an existing Phase I shallow well. Generally, the monitoring wells are planned to further assess the nature and extent of groundwater contamination detected at the site in Phase I. The planned locations of the monitoring wells are shown on Figure 4-6. Table 4-5 summarizes site groundwater collection activities. In general, the monitoring wells are located to determine the ground water quality upgradient of the site, the groundwater quality at the downgradient edges of the site, and the extent of site groundwater contamination. The rationale for each of the planned well locations is provided in Section 3.0.

4.2.8.1 Technical Approach

Sampling and analysis of groundwater will be conducted for all 18 site monitoring wells. The sampling of newly installed and existing wells will be conducted no sooner than one week after well development to allow for equilibration.

Work elements for the monitoring well groundwater sampling task include the following:

- Collect head space measurements from the casing of each well prior to obtaining water level measurements before purging
- Measure water levels in wells to be sampled
- Purge wells using Low-Flow methodology
- Measure pH, temperature, specific conductivity, dissolved oxygen, redox potential, salinity, and turbidity periodically during the extraction of water from the well
- Collect samples using Low-Flow methodology
- Document, package, and ship all samples for chemical analysis

A single round of water level readings will be taken during each sampling event prior to initiation of sampling activities. Measurements will be taken with an electronic water-level indicator (e.g. M-scope) or popper, using a marked point on the top of the well casing as the reference point for determining depths to water. Water level measurements will be recorded to the nearest 0.01 foot. The measuring device will be calibrated with a steel measuring tape and decontaminated prior to use. The measuring device will also be decontaminated between use in each well. Decontamination will be performed by rinsing with deionized water and allowing to air dry. Additionally, at those sites where the presence of a NAPL is anticipated due to previous site information or as potentially indicated by observations made during well development, the presence of NAPLs will be assessed (e.g., the thickness of the NAPL will be determined) prior to sampling with an oil/water interface probe. At a minimum, the interface probe will be decontaminated with non-phosphate detergent, tap water, methanol, hexane, tap water, and then deionized water after each use. NAPLs known to exist in a well will be sampled prior to purging. All water level readings will be completed within an 8-hour period without excessive rainfall. All samples will be collected within two weeks of the initial water level measurements.

4.2.8.2 Low Flow Sampling Procedure

The low-flow sampling methodology using a submersible pump or peristaltic pump will be used for purging and collecting all groundwater samples from site wells. In the event that field conditions preclude the use of low flow sampling in a well, a centrifugal pump or a stainless steel bailer will be used to sample that well.

For each well, the low flow sampling procedures to be followed will include:

1. Prior to taking water level measurements, head space readings will be collected and recorded for each well, using a FID or a PID.

2. The depth to water in the well will be measured and recorded with the M-scope to the nearest 0.01 feet; (minimize immersion of the M-scope probe within the standing water column to avoid disturbance of colloidal particles).

3. The required length of tubing will be calculated, measured, and marked with duct tape for attachment to either the submersible or the peristaltic pump, such that the intake (submersible pump, or tubing intake if peristaltic used) is placed at the midpoint of the saturated screened interval, if known, or at a depth selected by NORTH DIV if the screened interval is unknown. Note that the tubing will be measured to allow a minimum distance between the well head and the discharge point (field testing

equipment), to minimize temperature changes in the groundwater discharged from the well. Teflon or teflon lined tubing will be used and disposed of after sampling is complete.

4. The pump and/or tubing will be slowly and smoothly lowered to the required depth to minimize the amount of mixing in the well. The pump cable and/or discharge tubing will be secured to the well casing (or PVC stick-up) to minimize movement.

5. The field testing equipment (and peristaltic pump head, if used), will be calibrated, assembled, and placed as close as possible to the well head/discharge tubing. For the peristaltic pump, the discharge tubing will be connected to the pump head with a minimum length of silicone tubing.

6. The pump will be connected to the power supply (generator or other power source, i.e., battery, for remote peristaltic pump locations) and the power supply turned on (without starting the pump).

7. The depth to water with the pump and/or tubing in the well will be re-measured and compared with the initial reading; if the readings vary by greater than 0.05 feet, field personnel will wait for five minutes, remeasure the water, and begin pumping.

8. The pump will be started at the lowest flow setting (attempt 100 to 200 milliliters per minute). The pump start time will be recorded and the flow rate will be measured and recorded using a graduated measuring device and stopwatch. (Note that during the initial period of pumping, an estimated initial 5 to 10 minutes, the depth to water in the well should be measured frequently (at an estimated frequency of approximately once per minute), to enable timely pump flow adjustments to attempt to minimize significant drawdown in the well).

9. The initial groundwater sample discharged from the tubing will be collected and field parameters (pH, temperature, conductivity, turbidity, salinity, redox potential, dissolved oxygen, and the time the measurements are taken) will be measured and recorded.

10. These field parameters (pH, temperature, conductivity, turbidity, salinity, redox potential, and dissolved oxygen) and the depth to water in the well (using the M-scope) will be measured at 5-minute intervals (initially the water level will be measured more frequently, as discussed in step 8 above). The data and the associated time will be

recorded on the low-flow sampling data sheet. Attempts will be made to maintain the drawdown in the well during pumping to 0.3 feet or less, by adjusting the pump flow rate. Drawdown for each well will vary depending on the recharge capacity of the well. Drawdown may exceed 0.3 feet in some or all wells.

11. Following the stabilization of measured field parameters, groundwater samples will be collected. "Stabilization" of readings will be readings within plus or minus ten percent for three consecutive five-minute readings, or up to 3.0 well volumes purged, if readings have not stabilized prior to purging 3.0 well volumes. Turbidity values are expected to be 10 NTUs or less at stabilization, however, the location of the well with respect to the contaminant source may result in turbidity readings that are "naturally" above 10 NTUs.

Following purging procedures, samples will be collected directly through the tubing into appropriate sample bottles. For VOC analysis, the sample aliquot will be collected directly into a prepreserved 40 ml vial. VOA samples will not be opened after collection. An extra vial will be collected to check the pH of the sample. If the desired pH is not obtained, five drops of HCl will be placed into new 40 ml vials and the sample will be recollected. The order of sample bottle filling is as follows: TCL VOC (immediately upon completion of purging the well), TCL BNA, TCL pesticides/PCBs, and TAL metals, cyanide, and general chemistry samples (BOD, COD, TSS).

All pertinent field data will be recorded on Sample Log Sheets and referenced in the field logbook. Appropriate chain-of-custody procedures will be followed (see Section 4.4). Samples will be labelled, preserved, packed, and shipped according to HNUS SOPs.

Analytical parameters are provided on Table 4-1. Required sample containers for groundwater samples are provided in Table 4-2. Table 4-3 summarizes the quality control samples to be collected. Groundwater sampling is summarized on Table 4-5.

Groundwater samples will be analyzed for the full TCL/TAL and total chloride. Additionally, three shallow and two bedrock wells (MW5, MW10S, MW10R, MW13S, and MW13R) will be sampled for dissolved metals analysis (field filtered), as well as analyzed for BOD, COD, and total suspended solids for ground water treatability information.

Preservation Methods

Aqueous samples will be placed in the appropriate sample containers and preserved with appropriate reagents, as indicated in Table 4-2. Metal aqueous samples will receive approximately 2 ml of nitric acid. The sample bottle will be capped and then inverted to distribute the preservative until homogeneous. The cap will be removed and a portion of the sample for testing pH will be poured into a disposable beaker. Narrow range pH paper will be used to determine the required pH of the water as indicated in Table 4-2. If the desired Ph is not obtained, this method will be repeated until the desired pH is reached. VOC aqueous sample bottles will be pre-preserved with HCl by placing 2 drops of 1:1 HCl in the VOC vial. VOC sample bottles will not be re-opened after sample collection. (An extra VOC vial will be collected and checked for pH values, then discarded).

All samples will be stored and shipped on ice following sample collection, with the exception of preserved aqueous metals samples, which do not require storage on ice following preservation.

4.2.9 Subtask 0309 - In-Situ Hydraulic Conductivity Testing (Slug Testing)

Both rising head and falling head hydraulic tests (slug tests) will be performed on the four newly installed bedrock wells and on six selected overburden wells to help determine the bulk hydraulic conductivity of the aquifer(s) beneath the area of investigation. The overburden wells to be tested will be determined using data (soil classification and pumping response) collected during the soil boring and well installation programs.

Prior to initiation of slug testing at each selected well, water level will be measured to the nearest one-hundredth of a foot using an electronic water level meter. After the static water level has been established, a decontaminated PVC slug (of known diameter and length) will be lowered into the well just above the water table. The slug will be dropped "instantaneously" so that its entire length will be below the water table. Water level measurements will be taken at regular intervals as the water "falls" back to its initial static level (falling head test).

Once the water level has again returned to static conditions, a rising head test will be conducted by withdrawing the slug from the well, and measuring the water level at regular intervals, a procedure identical to that used for the falling head test. The slug will be decontaminated between wells (to prevent cross-contamination) by rinsing with a non-phosphate soap solution, tap water rinse, dilute nitric acid rinse, distilled water rinse, methanol rinse, and hexane rinse followed by a final deionized water rinse.

Slug testing procedures and recording requirements are described in SOP GH-2.4 (see Appendix C).

4.2.10 Subtask 0310 - Tidal Influence Evaluation

Given that the Melville North Landfill Site is immediately adjacent to Narragansett Bay, the possibility exists that ocean tidal patterns could influence groundwater flow on the site. HNUS will conduct a three month groundwater elevation monitoring program on three site will clusters (MW-6S/R, MW-10S/R, and MW-13S/R) to determine if such a tidal influence exists. Upon completion of groundwater sampling, each of these three well clusters will be equipped with an In-Situ 2-channel data logging device to measure both overburden and bedrock groundwater elevation changes over a three month period (programmed measurement frequency will be once per hour). Each data logger will be secured to the protective steel casing of a well and the well casing will be enclosed in a protective structure to minimize the possibility of weather, accident, vandalism, or theft interfering with the test.

A site visit will be made one week after installation to ensure the proper operation of the equipment. Data collected will be downloaded to a portable computer and field checked to confirm data collection. Subsequent site inspection/data collection events will occur at the end of the first 30 days, 60 days, and 90 days after initial installation. The test will be ended after 90 days and all equipment will be demobilized from the site.

Data collected from each well will be downloaded onto a personal computer. Measured tidal elevations for the area will be input into the computer and compared to the groundwater data to determine to what extent the site groundwater flow is affected by tidal influences.

4.2.11 Subtask 0311 - Topographic Survey

Following completion of field sampling activities, the site will be surveyed by a State of Rhode Island registered surveyor. The location and elevation of physical site features, previously installed wells, newly installed wells, soil boring locations, surface soil sample locations, wetlands boundaries, and sediment sample locations will be determined in the survey. Each sample location will be referenced to the State of Rhode Island Grid Coordinate System. Completed monitoring wells will be surveyed for elevation at the top of the protective casing, the top the well casing, and on/at an adjacent land surface. Elevations will be referenced to mean low water. The survey information will be retained as an Autocad Release 12 file. Horizontal control for the landfill is assumed to be available.

4.3 SAMPLE DESIGNATION SYSTEM

Each sample taken from the Melville North Landfill study area will be assigned a unique sample tracking number. This number will consist of a three- to four-segment, alpha-numeric code that identifies the site, sample medium, specific sample location identifier, and sample depth, as appropriate. Any other pertinent information regarding sample identification will be recorded in the field logbooks or on sample log sheets.

The alpha-numeric coding to be used in the sample numbering system is explained in the following diagram and the subsequent definitions:

AAAA -	AA -	(varies)	- NNNN
(Site Identifier)	(Sample Medium and Method)	(Sample Location Identifier)	(Event or Depth)

Character type:

A = Alpha
N = Numeric

Site Identifier: Includes the site name and the property name

MNLF = Melville North Landfill

Sample Medium:

MW = Groundwater (Monitoring Well)
SB = Subsurface Soil (Soil borings)
SS = Surface Soil
SD = Sediment

Sample Location Identifier:

Sample location identifiers for monitoring wells will be the well number. Surface soil and sediment identifiers will be the station number assigned. Subsurface soil location identifiers will be the borehole the sample is collected from. For example, a groundwater sample collected from well number 125 would be designated as: MNLF-MW-125.

Sample or Depth: (Only applicable to Surface Soil and Subsurface Soil Samples)

Surface soil and subsurface soil samples will be assigned a four-digit sample depth number: the first two digits will represent the upper depth and the latter two digits will represent the lower depth of the sample interval (in inches or feet below ground surface) from which the sample was collected. For example, a surface soil sample collected from a depth of 0-3 inches or 6-12 inches below the ground surface will be number "0003" and "0612", respectively. A subsurface soil sample collected from a split-barrel sample depth of 6 to 8 feet below ground surface would be assigned a depth number of "0608".

Quality Control (QC) blanks will be labeled with the Site Identifier, Sample Medium, Type of QC Sample, and a consecutive sample-specific number. No sample location numbers will be applied to the QC blank samples:

AAAA - AA - AAAA - NN

For example, the first groundwater duplicate collected would be labeled MNLF-MW-DUPL-01. The first rinsate blank from a surface soil sample would be assigned the sample tracking number:

MNLF-SS-RB-01

Note: All Rinsate Blank samples must be sent to the lab for analysis, although half must be marked "hold for analysis". Analysis of these extra samples will be performed if determined necessary by the HNUS Project Manager.

4.4 STANDARD OPERATING PROCEDURES

Field sampling will include the collection of surface soil, subsurface soil, sediment, and groundwater, as well as QA/QC samples during the tasks described in Section 4.2. General field sampling and sample documentation procedures are described in Halliburton NUS' Standard Operating Procedures (SOPs) appended to this Work Plan (Appendix H). "GH" designates Geology/Hydrogeology field methods; "SA" designates Sampling Methods; "SF" designates Supporting Field Methods; and "ME"

designates Monitoring Equipment. Pertinent SOPs that may be applicable to this project include, but are not limited to:

- GH - 1.2 Evaluation of Existing Monitoring Wells
- GH - 1.3 Soil and Rock Sampling
- GH - 1.4 Soil and Rock Drilling Methods
- GH - 1.5 Borehole and Sample Logging
- GH - 1.6 Decontamination of Drilling Rigs and Monitoring Well Materials
- GH - 1.7 Groundwater Monitoring Point Installation
- GH - 2.4 In-Situ Hydraulic Conductivity Testing
- GH - 2.5 Water Level Measurement/Contour Mapping
- GH - 3.3 Seismic Refraction Surveys
- SA - 1.1 Groundwater Sample Acquisition
- SA - 1.2 Surface Water and Sediment Sampling
- SA - 4.2 Terrestrial Ecological Inventory and Sampling
- SA - 6.1 Sample Identification and Chain of Custody
- SA - 6.2 Sample Packaging and Shipping
- SA - 6.3 Site Logbook
- SA - 6.4 Forms used in RI Activities
- SF - 1.1 On-site Water Quality Testing
- SF - 1.2 Sample Preservation
- SF - 2.2 Waste Handling
- SF - 2.3 Decontamination of Chemical Shipping and Field Analytical Equipment
- ME - 01 HNU PI-101 Organic Vapor Meter
- ME - 02 Organic Vapor Analyzer
- ME - 04 Oxygen Meter
- ME - 05 Combustible Gas Indicator

4.5 SAMPLE CUSTODY AND SHIPPING PROCEDURES

To ensure the integrity of a sample from collection through analysis, an accurate, written record will be kept to trace the possession and handling of the sample. This documentation is referred to as the sample chain of custody (COC), which must be maintained at all times and documented in accordance with SOP SA-6.1. Chain of custody begins at the time the sample is collected and is maintained by storing the samples (on ice in coolers) in locked field vehicles or within view of HALLIBURTON NUS personnel. Sample documentation must also verify chain of custody throughout sample packaging, shipping, laboratory receipt, and analyses, as detailed in SOP SA-6.1.

Samples must be under the custody of the sampler or the Site Supervisor from the time of sample collection until the sample is shipped. At that time, the custody is maintained by the shipper and tracked with the shipping airbill. The final recipient is the representative who signs for the shipment at the laboratory.

All samples to be shipped for analysis will be labelled in accordance with the "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" by the Naval Energy and Environmental Support Activity (NEESA 20.2-047B). Sample labels shall include the following information:

- Site name
- Assigned sample number
- Date and time of sample collection
- Designation of the sample as a grab or composite
- Type of sample (matrix) and a brief description of the sampling location
- Signature of the sampler
- Sample preservation used
- Type of analysis to be conducted

An example of the sample label is included in Attachment G.

The chain of custody record that accompanies the samples through shipment to the laboratory will include the following information, as specified in the NEESA document referenced above:

- Project name
- Signature of samplers
- Assigned sample number
- Date and time of sample collection
- Designation of the sample as a grab or composite
- Sample matrix
- Brief description of the type of sample and sampling location
- Signatures of individuals involved in sample transfer (i.e. relinquishing and accepting samples) and date and time samples are relinquished and received

Prior to shipment, the method of shipment, the courier's name, and any other pertinent information shall be entered on the COC record. The original of the record shall be sealed in plastic inside the shipping container to accompany the shipment; a copy of the record shall be retained by field personnel. An example of the Chain-Of-Custody Record is included in Attachment G of this Work Plan.

4.6 QUALITY CONTROL SAMPLE COLLECTION

Quality control samples will be collected to ensure procedures followed are adequate to protect sample integrity. These will include:

- Rinsate blanks - Aliquots of laboratory grade water poured across sampling devices under field conditions. These blanks are analyzed to detect any contamination from the sampling equipment after it has been decontaminated.

- Trip blanks - Samples of laboratory grade water that accompany each shipping container from the field. These samples are used to detect cross-contamination between sealed sample containers during handling and transportation.

- Duplicates - Split samples shipped "blind" to the laboratory to document precision. The precision resulting from field duplicates is a function of the variance of waste composition, sampling technique, storage, shipping and handling, and the analytical technique.

- Field blanks - Samples of each water source used for decontamination (e.g., hydrant water used in steam cleaning, and deionized water used on equipment) and the water source used for the rinsate and trip blanks identified above (HPLC water).

A summary of quality control samples to be collected during this project are depicted in Table 4-3.

4.7 DECONTAMINATION PROCEDURES

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

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically, it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

An attempt will be made to structure the drilling program so that boring activity will proceed from less likely to more likely contaminated boring locations in order to reduce the potential for cross-contamination between locations.

The decontamination area will be installed by the subcontracted drilling company. The location will be determined during mobilization activities.

4.7.1 Drilling and Other Heavy Equipment

All down-hole drilling and sampling tools will be decontaminated by steam cleaning prior to each use.

4.7.2 Non-Disposable Sampling Equipment

All non-disposable sampling equipment that comes in contact with the sample medium will be decontaminated to prevent cross-contamination between sampling points. This includes equipment such as stainless-steel scoopulas, trowels, and bowls, and split-barrel samplers. The following decontamination sequence will be employed:

- Wash and scrub with a low phosphate detergent in potable water;
- Rinse with potable water;
- Rinse with 10 percent nitric acid (1 percent nitric acid on carbon split barrel samplers);
- Rinse with tap water;
- Rinse with methanol;
- Rinse with hexane pesticide grade solvents or better;
- Rinse with distilled water (analyte-free);
- Air-dry on clean polyethylene sheeting; and
- Wrap in aluminum foil, shiny side out for transport (if not being used immediately).

Note: Clean equipment may rest on, but never be wrapped in, clean polyethylene sheeting.

4.7.3 Sampling Pumps

4.7.3.1 Submersible Pump

- Upon removal of the pump from the well following sample collection, the pump will be submersed in a bucket containing a potable water and detergent (Alconox or Liquinox) solution, and the exterior surface will be scrubbed. A short length of tubing will be attached and at least 1 to 2 gallons of the detergent solution will be pumped through (start the pump at a low flow rate, as in sampling, and increase to a high speed).

- Remove the pump and rinse or spray with potable water to minimize transfer of soap to the rinse bucket.

- Submerse the pump in a bucket of potable water rinse and pump at least 1 to 2 gallons through (start the pump at a low flow rate, as in sampling, and increase to a high speed). Use a brush dedicated to the potable water rinse to scrub the exterior surface.

- Submerse the pump in a bucket of deionized/distilled water rinse and pump at least 1 to 2 gallons through (start the pump at a low flow rate, as in sampling, and increase to a high speed). Use a brush dedicated to the deionized water rinse to scrub the exterior surface.

- Remove the tubing used during decontamination; this tubing may be reused for decontamination purposes.

- Air dry and wrap the pump in clean aluminum foil (dull side towards pump).

4.7.3.2 Peristaltic Pump

Peristaltic pumps will not require additional decontamination since the pump does not come into contact with the sample media (a new length of unused silicone tubing will be used for each well to be sampled).

Note that tubing used for purging and sampling with pumps will not be decontaminated because it will either be left in the well for reuse or disposed of.

4.7.3.3 Filtration Equipment

For the in-line filter, decontamination is not required because the filter cartridge is disposable. However, the cartridge must be disposed of in an approved receptacle. The tubing used for sampling with the in-line filter will not be decontaminated because it will be disposed of.

4.7.3.4 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

4.7.3.5 Probes

For field analytical equipment such as pH, specific conductivity, and dissolved oxygen probes, etc., that include a sensitive probe that contacts the potentially contaminated groundwater, a thorough rinse using deionized water will be conducted following use (between wells).

4.7.4 Monitoring Equipment

All monitoring equipment will, to the extent possible, be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If decontamination of monitoring equipment is necessary, the following procedure will be utilized:

- remove gross contamination with potable water
- potable water/liquinox light wash
- light rinse with potable water

For probes that make no direct contact but may experience splattering, the probe will be wiped with clean paper towels or cloth wetted with alcohol.

All decontaminated rinsates will be collected and contained in drums for subsequent determination of proper handling and/or disposal.

4.8 INVESTIGATION-DERIVED WASTE PLAN

4.8.1 Introduction

This plan presents a discussion of the planned management procedures for all field generated or investigation derived waste materials. Investigation-derived waste (IDW) materials typically include soil boring drill cuttings, monitoring well development water and purge water, sampling equipment decontamination solutions, and disposable personnel protective equipment. During the field investigation activities, care will be taken to minimize the amount of IDW material that is generated and handled. The following sections provide the planned management and handling procedures for IDW materials during the field investigation activities.

4.8.2 Waste Management

Generally, IDW materials will be placed in DOT-approved 55-gallon drums. Drums will be filled to no more than 90 percent of capacity to allow for the potential expansion of the drum contents. Drums will be marked with sticker labels and indelible liquid chalk pens by field investigation personnel. Drum labels will be of a contrasting color (e.g., yellow) relative to the drums (e.g., black). Information recorded on the drums and labels will include:

- generator (US Navy, Naval Education Training Center, Newport, Rhode Island, 02841)
- generator EPA identification number,
- source (e.g., site number and name, well or boring number),
- date(s) of generation,
- matrix (e.g., soil, water, etc.), and
- notes/observations (e.g., odors, non-aqueous phase liquids, etc.)

The handling and disposal of all IDW materials will be coordinated by HNUS on behalf of the US Navy. The RIDEM and EPA Region I will be informed of the final disposition of all IDW material.

4.8.3 Waste Handling & Disposal

4.8.3.1 Soils

Solid material derived from the subsurface exploration program (e.g., auger spoils, split spoon samples, etc.) will be continuously observed for evidence of potential contamination (e.g., discoloration, odors, etc.) and monitored for the presence of VOCs using a PID or FID.

Drill cuttings produced from soil borings will be backfilled into their respective borings and a cement-bentonite grout will be placed in the top 1-foot of the borehole, as described in Section 4.2.6. Drill cuttings produced from monitoring well borings will be containerized in 55-gallon drums.

Drummed well boring cuttings remain at the boring location pending soil analytical results. If full scan (i.e., TCL organics and TAL inorganics) analytical results of soil samples from the soil boring and field observations (odors, discoloration, elevated PID or FID readings, etc.) indicate the absence of contamination, the associated drummed soil will be returned to the ground surface near the respective source well location. To ensure it will not interfere with future well sampling events, IDW material will not be placed closer than ten feet, nor further than twenty feet from its source location. The location(s) where any drill cuttings are placed will be recorded in a field notebook.

Soil cuttings that are determined by review of analytical results to be contaminated will be segregated and staged on site for subsequent disposal. HNUS will be responsible for staging all drums that are determined to require disposal. The designated on-site drum staging areas will be established during the field mobilization activities. Analytical results of soil samples collected from well borings will be used to aid in characterizing the associated drummed cuttings.

If characterization of the soil borings indicates that the drummed drill cuttings from that boring are hazardous, the drummed IDW materials will be transported by a licensed waste hauler for treatment or disposal in accordance with applicable state and federal regulations established under the Resource Conservation and Recovery Act (RCRA).

4.8.3.2 Well Water

All well water (e.g., purge and development water) produced from site monitoring wells will be containerized in 55-gallon drums. The presence/absence of a non-aqueous phase liquid will be assessed in each well during well development, purging, and sampling. Any nonaqueous phase liquids

or evidence of possible petroleum contamination (i.e., sheen, odor, elevated OVA response) that are detected or observed in the well will be recorded in a field notebook.

Analytical results of the ground water samples collected from the well will be used to aid in characterizing the drum contents. If associated ground water sample TCL/TAL analytical results and field observations (e.g., odors, sheen, elevated OVA response) indicate the absence of contamination, the associated drummed well water will be discharged onto the ground in the vicinity of the respective source well. The well water will not be discharged closer than ten feet, nor further than twenty feet from its source well. The location(s) of the discharged well water will be recorded in a field notebook. The EPA Region I and RIDEM will be consulted prior to discharging any IDW material on the sites.

If field observations and/or associated sample data indicate that the well water is contaminated, a subcontractor will be procured and the drummed material will be transported for treatment by a licensed hauler in accordance with local, state, and federal regulations. The treatment of wastewaters at a local publicly-owned treatment works will be considered, if appropriate.

4.8.3.3 Decontamination Solutions

Downhole drilling equipment (e.g., augers, rods, cutting heads) will be steam cleaned prior to each use. Steam cleaning will be conducted in a designated heavy equipment decontamination area. Rinse waters from steam cleaning will be recovered and contained in 55-gallon drums for characterization and appropriate off-site treatment/disposal.

Sediment/soil generated from steam cleaning operations will be drummed separately at the decontamination area for appropriate characterization and proper disposal.

Chemical (e.g., hexane, methanol, nitric acid) and water (distilled and tap) mixtures used to decontaminate sampling equipment (e.g., split spoons) will be separately collected, containerized, and labelled for proper treatment or disposal.

4.8.3.4 Disposable Equipment

Disposable equipment (e.g., tyvek coveralls, gloves, boot covers, etc.) will be decontaminated (rinsed and if necessary, scrubbed) placed into doubly-lined trash bags, and disposed of in the on site refuse container. Refuse containers to be used for such disposal will be designated by the NETC Public Works Department. Expendable equipment that is known or believed to be contaminated (e.g., oily gloves)

will not be disposed of in the on site refuse container. Such equipment will be drummed, labelled, and segregated for disposal.

4.9 CALIBRATION AND MAINTENANCE OF INSTRUMENTS

Analytical instruments used will be calibrated daily in accordance with the manufacturers recommendations. Records of calibration will be maintained on site until completion of the project and thereafter will be made a permanent part of the project file.

Maintenance of the equipment and instruments shall also be performed in accordance with the manufacturers requirements and in accordance with Halliburton NUS Standard Operating Procedures, as described in Section 4.4 of this Work Plan.

4.10 DATA VALIDATION

The results of samples analyzed for TCL Volatile Organic Compounds, TCL Base Neutral and Acid Extractable Compounds, TCL Pesticide/PCBs, Total TAL Metals and cyanide, and TAL Metals (Dissolved) using CLP SOW 3/90 (w/revisions) procedures will be validated using "Level D" protocols specified in "National Functional Guidelines for Organic/Inorganic Data Review" (U.S. EPA 12/90, rev.6/91 [organic]). Use of these validation protocols are in accordance with the NEESA 20.2-047B; 6/88 guidelines.

5.0 QUALITY ASSURANCE PROJECT PLAN

5.1 PROJECT DESCRIPTION

5.1.1 Introduction

This Quality Assurance Project Plan (QAPP) has been developed for use in conjunction with Phase II Remedial Investigation sampling activities at the Naval Education and Training Center (NETC) in Newport, Rhode Island. This Phase II sampling program builds on the findings of previous site studies conducted at NETC-Newport under the Navy Assessment and Control of Installation Pollutants (NACIP) program. Previous site studies included an Initial Assessment Study (IAS) conducted in 1983, and the first phase of the NACIP Confirmation Study procedure, the Verification Step study, which was completed in 1986, and the Phase I Remedial Investigation which was completed in 1991.

Navy policy calls for following EPA guidance and procedures while conducting investigations and remedial action at all Navy waste sites. The specific tasks outlined in the current Navy Installation Restoration (IR) Program are consistent with EPA guidance, and provide a structure for conducting an RI/FS based on the National Contingency Plan (NCP). This project entails the planning process for the second phase of the RI/FS investigation. The work plan for the RI is designed to characterize the nature and extent of contamination; verify the probable contaminant sources; and collect data to evaluate the need for remedial action(s). The RI sampling program is designed to meet all applicable guidance for Superfund, RCRA, and the Navy IR program.

The QAPP serves as a controlling mechanism during field sampling, sample laboratory analysis, and data validation to ensure all data collected are valid, reliable, and legally-defensible. The QAPP outlines the organization, objectives, and all Quality Assurance/Quality Control (QA/QC) activities which will ensure achievement of desired data quality goals.

5.1.2 Location

The Naval Education and Training Center (NETC) is located within the Newport Naval Base, which encompasses approximately six miles of the western shore of Aquidneck Island, Newport County, Rhode Island. Aquidneck Island is comprised of three towns; Newport, Middletown, and Portsmouth. A map of the relative locations of NETC area is provided as Figure 1. NETC serves as a training facility and provides logistic support for the Newport Naval Base. NETC occupies approximately 1,063 acres of land.

5.1.3 History

Extensive information on the history of the Newport Naval Base was presented in the Initial Assessment Study (Envirodyne Engineers, 1983). Text from this report has been excerpted and referenced with appropriate page numbers below.

"The Newport area was first used by the Navy during the Civil War when the Naval Academy was moved from Annapolis, Maryland to Newport in order to protect it from Confederate troops. The Naval Academy operated at Newport for about four years before returning to Annapolis.

In 1869, the experimental Torpedo Station at Goat Island was established. This was the Navy's first permanent activity at Newport. The station was responsible for developing torpedoes and conducting experimental work on other forms of Naval ordnance.

In 1881, Coasters Harbor Island was acquired by the Navy from the City of Newport and used for training purposes. In 1884, the Naval War College was established on the island. A causeway and bridge linking the island to the mainland was constructed in 1892. In 1894, the USS Constellation was permanently anchored as a training ship for the Naval War College.

The Melville area was established as a coaling station for the steam-powered ships in 1900. The Navy purchased 160 acres of land and constructed the Narragansett Bay Coal Depot. With the advent of ships burning liquid fuel, it became necessary to add oil tanks. Consequently, in 1910, four fuel oil tanks were added in the Melville area. These tanks are still used today.

In 1913, the Navy established the Naval Hospital on the mainland of Aquidneck Island. At this time the main hospital building was constructed.

The outbreak of Word War I caused a significant increase in military activity at Newport. Some 1,700 men were sent to Newport and housed in tents on Coddington Point and Coasters Harbor Island. A bridge was built at this time connecting Coddington Point with Coasters Harbor Island. In 1918, Coddington Point was purchased by the Navy. Much of the base organization was then transferred to Coddington Point. During the war, numerous destroyers and cruisers were fueled by the Melville Coal Depot and fuel tanks. By this time, a pipeline had been extended to the north fueling pier and two additional oil tanks constructed.

Following World War I, fuel oil gradually replaced the use of coal by the Navy fleet. In 1921, the Coal Depot was changed to the Navy Fuel Depot. In 1931, the coal barges and coaling equipment were sold to the highest bidder.

In 1923, some two hundred buildings, which were part of the emergency war camps established on Coddington Point, were stripped and sold for scrap. The base remained relatively inactive until the onset of World War II.

Reactivation of the base occurred in the late 1930's as a result of military build-up in Europe. Just prior to the reactivation, a 1938 hurricane and tidal wave had destroyed or severely damaged over 100 buildings and much of the sea walls. In 1940, Coddington Cove was acquired for use as a supply station, and hundreds of Quonset huts were constructed throughout the base. Additional barracks were constructed on Coasters Harbor Island, increasing the base housing capacity to over 3,500 men. Power plant facilities were also constructed at this time. Coddington Point was reactivated to house thousands of recruits. The Anchorage housing complex in the Coddington Cove area was constructed in 1942. In the Melville area, additional fuel facilities were constructed along with a Motor Torpedo Squadron Boat Training Center and nets for harbor defense. Tank Farms 1 through 5 were constructed during this time period. The Fire Fighting School, Fire Control Training Building, and the Steam Engineering Building were constructed in 1944.

The Torpedo Station at Goat Island was very active during World War II and had expanded its operation to Gould Island. The Torpedo Station employed more than 13,000 people and manufactured 80 percent of all torpedoes used by our country during the war. The station was the largest single industry ever operated in Rhode Island.

Following World War II, naval activities at Newport converted to a peace time status. This resulted in a reduction of naval activity. Some 300 Quonset huts and buildings were removed, and the entire naval complex was consolidated into a single naval command designated the U.S. Naval Base in 1946.

The Naval Base adjusted to its peace time status by increasing its activities in the fields of research and development, specialized training, and preparedness for modern warfare. There was a brief period during the Korean War when some 25,000 sailors trained at Newport.

In 1951, the Torpedo Station was permanently disestablished after 83 years of service. Future manufacture of torpedoes was to be awarded to private industry. In place of the Torpedo

Station, a new research and development facility, the Naval Underwater Ordnance Station, was established and given the responsibility of overseeing the private contractors. The Officer Candidate School was also established in 1951.

In 1952, the Training Station and other naval schools were disestablished, and the U.S. Naval Station and the U.S. Naval Schools Command were established.

In 1955, Pier 1 was constructed, with Pier 2 being added in 1957. Newport became the headquarters of the Commander Cruiser-Destroyer Force Atlantic in 1962. Some 55 naval warships and auxiliary craft were homeported at Newport. New housing and bachelor quarters were added in the late 1950's and early 1960's.

Major expansion of the Naval War College occurred during the late 1950's and early 1970's, transforming the college into a major university. In July of 1971, The Naval Schools Command was restructured and named the Naval Officer Training Center (NOTC).

In April of 1973, the Shore Establishment Realignment Program (SER) was announced and resulted in the largest reorganization of Naval forces in the Newport Area. The fleet stationed in Newport was relocated to other naval stations on the east coast. SER resulted in the disestablishment of the Naval Communication Station and the Fleet Training Center and related activities. The Public Works Center, Naval Supply Center, Naval Station and Naval Base were absorbed by NOTC. In April of 1974, NOTC was changed to the Naval Education and Training Center (NETC).

The drastic changes which resulted from SER caused a reduction of Navy personnel, both military and civilian, in excess of 14,000. Coupled with the reductions at the Naval Construction Battalion Center at Davisville, and the closure of the Naval Air Station at Quonset Point, SER had severe economic impacts in the Narragansett Bay area.

The reorganization brought about by SER resulted in the Navy excessing some 1,629 [1,374] acres of its 2,420 [2,805] acres. Some of the land has been leased to the State of Rhode Island pending final sale of the land by the General Services Administration.... The Navy also leases 44 acres of land in Coddington Cove to the State of Rhode Island and Economic Development Corporation. The state has subleased this property to a private enterprise engaging in shipbuilding and repair. Also, a fish food processing operation utilizes the cold storage warehouse in Building 42 near Pier 1.

The above information on the history of the installation was obtained from the most recent Master Plan (NORTHDIV, 1980), the 1981 Annual Report of the Navy in the Rhode Island Area (NETC Public Affairs Office, 1981), and the Command Histories at the Naval History Office in Washington, D.C."

(pp. 5-6 to 5-14)

5.1.4 Previous Site Investigations

The NETC facility has been under assessment through the Department of the Navy's Assessment and Control of Installation Pollutants (NACIP) program. The NACIP program was established to identify and control environmental contamination from past use and disposal of hazardous substances at Naval installations. The NACIP program is part of the Department of Defense Installation Restoration Program, which is similar to the U.S. EPA's Superfund program authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

The NACIP program consists of three phases: Phase I - Initial Assessment Study (IAS), Phase II - Confirmation Study (CS), and Phase III - Remedial Measures phase.

The IAS (Envirodyne Engineers, 1983) identified areas where potential contamination from past waste storage, handling, or disposal practices may pose threats to human health or the environment. Eighteen potentially contaminated areas were identified in the IAS report. Two of the areas were subsequently found to be outside of the scope of the NACIP program and were not discussed further in the report. The IAS concluded that no further action was required at three of the areas. Further investigation was recommended at the remaining thirteen areas.

A Confirmation Study was conducted at six of the thirteen areas recommended for further investigation. Table 1 provides a summary of the IAS recommendations for further study, at the sixteen sites reviewed. Three of the four RI sites were investigated under a Confirmation Study.

Confirmation studies were conducted for three of the five RI sites. The Confirmation Studies (Loureiro Engineering, 1986) conducted at McAllister Point Landfill, Tank Farm Four, and Melville North Landfill consisted of two steps: a Verification Step and a Characterization Step. The objectives of the Verification Step were to locate sources of contamination, determine the presence of specific toxic and hazardous materials, and determine general site hydrogeology. The objective of the Characterization Step was to develop a quantitative assessment of the contamination identified in the Verification Step.

Under the IR Program, Phase I Remedial Investigations (RI) have been conducted at five of the IAS sites on the NETC. The findings of the Phase I RI are presented in a draft RI report (TRC-EC, 1991).

5.1.5 Current Site Investigations

A Phase II Remedial Investigation will be conducted at the Melville North Landfill site. The planned Phase II RI field activities for this non-NPL site are presented in Volume III of this Work Plan.

5.1.6 Project Scope

An objective of this Remedial Investigation program is to gather sufficient information on the nature and extent of contamination at each site. The results of the Remedial Investigations should enable a technically-supported judgement as to whether specific site conditions constitute environmental, health or safety hazards.

The field activities and the associated sample matrices analyses for this site investigation will be discussed in this Work Plan. The sample program makes extensive use of Target Compound List (TCL) and Target Analyte List (TAL) analyses using EPA-CLP protocols, as defined in the USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; revised July 1991, and in the USEPA CLP SOW for Inorganic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; revised September 1991. These EPA CLP requirements will be followed during this study. Naval Energy and Environmental Support Activity (NEESA) guidance (Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program, NEESA 20.2-047B, 1988) for Level D analyses and data validation will also be followed by the laboratory and data validator. Where EPA-CLP protocols and NEESA guidance differ, the more stringent requirements will be followed.

Additionally, subsurface soil samples will be analyzed for Total Organic Carbon (TOC), Cation Exchange Capacity (CEC), and grain size distribution. Groundwater samples will also be analyzed for total chloride, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS). Sediment samples will additionally be analyzed for TOC, grain size distribution, acid volatile sulfide, and simultaneous extractable metals. Epa approved methods and detection limits will be used for analyses of these aforementioned miscellaneous analytical parameters.

5.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

5.2.1 Introduction

This project will be largely performed by Halliburton NUS Corporation (HNUS). HNUS has been charged with implementing the TRC-Environmental Corporations (TRC-EC) planning documents. Project review will be performed by a Technical Review Committee assembled by the Northern Division. The names and addresses of select individuals involved in the project review and oversight appear below.

U.S. Navy

- Northern Division Code 1823
  Naval Facilities Engineering Command
  10 Industrial Highway, Mail Stop #82
  Lester, PA 19113

  Ms. Deborah Carlson, Engineer-In-Charge
  (215) 595-0567

- Naval Education and Training Center
  Public Works Dept., Bldg. 1
  Newport, RI

  Mr. Brad Wheeler
  (401) 841-3735

Rhode Island DEM

- Air and Hazardous Materials Division
  291 Promenade Street
  Providence, RI 02908

  Mr. Paul Kulpa
  (401) 277-2797

HNUS

- Halliburton NUS Corporation
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  Mr. John J. Trepanowski P.E., Program Manager
  Mr. Mike Turco, Deputy Program Manager
  (610) 971-0900

- Halliburton NUS Corporation
  187 Ballardvale Street
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  Mr. Kevin Scully, Project Manager
  (508) 658-7899

- Halliburton NUS Corporation
  Foster Plaza 7, 661 Andersen Dr.
  Pittsburgh, Pennsylvania 15220-2745

  (412) 921-7090

  Ms. Debra A. Scheib, Program Quality Assurance Manager
  Mr. Matthew Soltis C.I.H, Health and Safety Officer

Figure 5-1 presents the organizational chart for the NETC - Newport RI/FS project showing staff positions responsible for each project element. The responsibilities of HNUS's Project Manager and QA/QC staff are briefly described below.

5.2.2 Project Manager's Responsibility

The HNUS Project Manager will provide overall direction to the project team, and will be held responsible for successful project completion. The Project Manager will be the primary contact for the Northern Division's Engineer-In-Charge (EIC).

5.2.3 QA Manager's Responsibility

The Halliburton NUS CLEAN Quality Assurance Manager (QAM) (or designee) will be the responsible Quality Assurance Officer for this project. The QAM (or designee) will serve as the HNUS primary contact with the Northern Division's QA staff, if so requested by the EIC. The QAM will monitor compliance of the project with the QAPP plan, and perform any necessary performance or system audits.

The HNUS QAM will initiate and monitor any necessary formal corrective actions. She will assist in preparing QA/QC project summaries for the RI Report, including analysis of precision, accuracy, and completeness of data collected.

5.2.4 Field QC Coordinator's Responsibilities

A Field QC Coordinator will be selected for this project. The Field QC Coordinator will work with the field team in preparing for the sampling events, and also during the field work. He or she will be on site to ensure required QC procedures are followed for sample collection and handling; will initiate informal and/or formal corrective actions, as necessary; and will maintain and report QC records and results to the HNUS Project Manager and QA Officer. The QC field coordinator will also serve as the QA/QC Manager for the project. This person will be responsible for ensuring all analytical deliverables have been received and subsequently validated in accordance with this QAPP.

5.2.5 Laboratory QC Coordinator

The analytical laboratory selected for this project, a NEESA-approved and EPA CLP laboratory, will also designate a QC Coordinator who will function as part of the project QC team. The duties of the laboratory QC Coordinator or designee will include, at a minimum, the following:

- Direct preparation of sample containers;
- Direct preparation and inclusion of blind QC samples in sample load in a fashion unrecognizable to analysts;
- Monitor use of known QC samples, blanks and duplicates, as required by specific projects;

- Maintain records of performance on known and blind QC samples as a measure of analytical precision and accuracy (control charts, etc.); and

- Direct and monitor recordkeeping and sample tracking activities.

5.3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

5.3.1 Introduction

The overall quality assurance objective for laboratory analysis of environmental samples is to provide a laboratory QA/QC program that is, at a minimum, equal to the U.S. EPA Contract Laboratory Program (CLP). The quality control limits of accuracy and precision for laboratory analyses are governed by the methods and equipment used. Laboratory QA/QC requirements defined in CLP protocol are designed to ensure that acceptable levels of data accuracy and precision are maintained throughout the analytical program. These requirements are detailed in the U.S. EPA CLP Statement of Work (SOW) for Organic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; revised August 1991 and in the U.S. EPA CLP SOW for Inorganic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; March 1990. These requirements will be followed during this study. In addition, Navy NEESA Level D analysis requirements will be followed when more stringent.

It must be recognized that QA objectives may be attainable only for samples that are homogeneous and do not have inherent matrix-related problems. In the event that QA objectives cannot be met on specific samples, groups of samples or sample types, the analytical laboratory will make every reasonable effort to determine the cause of non-attainment and, if such is due to instrument malfunction, operator error, or other identifiable cause within the control of the laboratory, the samples affected will be reanalyzed, if possible. Should non-attainment of QA objectives be due to sample inhomogeneity, sample matrix interference, or other sample-related causes, reanalyses will be treated as additional analyses.

For many EPA-approved methods, interlaboratory method verification studies have been used to establish QC criteria which may be regarded as an inherent part of the method. In those cases, such criteria will take precedence except for deviations from such criteria that can be reasonably attributed to sample-related cases.

The quality assurance objectives for all measurement data include considerations of precision, accuracy, completeness, representativeness, and comparability as described below.

5.3.2 Precision and Accuracy

The precision of a measurement is an expression of mutual agreement of multiple measurement values of the same property conducted under prescribed similar conditions. Precision reflects the repeatability of the measurement. Precision is evaluated most directly by recording and comparing multiple measurements of the same parameter on the same sample under the same conditions. Precision is usually expressed in terms of the standard deviation. The precision objectives for analytical parameters are specified in the CLP protocols. Except as otherwise specified by the method, the QC objective for precision under this project will be ± 20 percent (relative percent difference) as determined by duplicate analyses. It must be recognized that for analytes at concentrations of less than five times the method detection limit (MDL), this objective is unlikely to be met.

The degree of accuracy of a measurement is based on a comparison of the measured value with an accepted reference or true value, or is a measure of system bias. Accuracy of an analytical procedure is best determined based on analysis of a known or "spiked" sample quantity. The degree of accuracy and the recovery of analyte to be expected for the analysis of QA samples and spiked samples is dependent upon the matrix, method of analysis, and compound or element being determined. The concentration of the analyte relative to the detection limit is also a major factor in determining the accuracy of the measurement. Except as otherwise specified by a method, the QC objective for accuracy under this project will be 75 to 125 percent (percent recovery), as determined by sample spike recoveries. Alternately, accuracy may be assessed through the analyses of appropriate standard reference materials, certified standards, or samples, as available.

5.3.3 Completeness

Completeness is a measure of the amount of valid data obtained from the measurement system relative to the amount anticipated under ideal conditions. This project's QC objective for completeness, as determined by the percentage of valid data generated, will be ≥ 90 percent.

5.3.4 Representativeness

Samples taken must be representative of the population. Where appropriate, the population will be statistically characterized to express: 1) the degree to which the data accurately and precisely represent a characteristic of a population, 2) parameter variations at a sampling point, and 3) a process, or an environmental condition. Sample selection and handling procedures will be conducted to obtain the most representative sample possible. Sampling devices will be

decontaminated between sampling points to ensure that cross-contamination does not occur between samples.

Representativeness will also be monitored by collection and analysis of the following QC field samples:

- Trip blanks;
- Rinsate blanks;
- Source water blanks; and
- Duplicate samples.

These QC samples will be collected in accordance with Section 4.4 of the QAPP. Representative samples will be collected through the following actions:

- Collect samples from locations fully representing the site conditions;
- Use appropriate sampling procedures and equipment;
- Use appropriate analytical methodologies; and
- Analyze for appropriate parameters using appropriate detection limits.

Field duplicate and field quality control blank samples will be shipped as blind samples to the laboratory. These samples will be numbered similarly to other samples except fictitious sample identifiers will be assigned. Trip blanks will be labelled as such and shipped with samples being analyzed for volatile organics. Samples for matrix spike and matrix spike duplicates will be designated on the chain-of-custody forms and sample labels. Water samples for matrix spike and matrix spike duplicate analyses for organic parameters will be collected in triplicate; samples for matrix spike analyses for inorganic parameters will be collected in duplicate.

The laboratory will make appropriate efforts to assure that the samples are adequately homogenized prior to taking aliquots for analysis, so reported results represent samples received. Some techniques of homogenization (e.g., compositing) expose the sample to significant risk of contamination or loss through volatilization, and will be avoided.

5.3.5 Comparability

Consistency in sample acquisition, handling, analysis and level of QA/QC is necessary so that the analytical results may be compared. Where appropriate, the results of the analyses will be compared with the results obtained in previous studies. The laboratory will also use EPA-approved methods and

reporting units, in order to assure that the data will be comparable to other similarly generated data sets.

5.4 SAMPLING PROCEDURES

5.4.1 Introduction

The following matrices will be sampled during the Phase II field investigation study at NETC - Newport: surface soil, subsurface soil, sediment and ground water. All sample collection and monitoring methodology are presented in Appendix B of Volume III of this Work Plan. These procedures will be implemented in order to collect representative data for remedial planning guidance. All sample media collected will be handled in accordance with this Quality Assurance Project Plan and the Field Sampling Plan. All analytical methods and estimated detection limits are subsequently described in Section 5.7 of this document, including analysis for the Target Compound List (TCL) and Target Analyte List (TAL), as well as all other parameters for this project.

5.4.2 Selection of Sampling Locations

The sample locations for the Phase II RI at the Melville North Landfill site are presented in the Field Sampling Plan in Volume III of this Work Plan.

5.4.3 Sample Collection, Handling, and Shipping

It is important to use appropriate sample containers so that no chemical alteration occurs between the collection of samples in the field, and the receipt of samples at the laboratory. The sample bottles will be prepared and shipped to the field by the laboratory, under the direction of the laboratory QC coordinator. The sample bottles will be transported to the site within a sealed shipping cooler.

Sample containers will be selected to ensure compatibility with the potential contaminants and to minimize breakage during transportation. Aqueous phase samples for organic analyses will be contained in glass vials with teflon-lined, screw-type caps. The analytical methodologies to be employed at NETC - Newport, and the number of samples to be collected per matrix are displayed in Table 4-1. Bottleware, holding time and preservation requirements are listed in Table 4-2.

Sample labels will be filled out at the time of sampling and will be affixed to each container to identify the sample number, collector's name, date and time of collection, location of the sampling point, preservatives added, and analyses requested for the sample.

Ground water samples collected from all wells will be analyzed for total metals and 30 percent of these samples will also be analyzed for dissolved metals. Consequently, filtering will be conducted in the field prior to the addition of preservatives. Water samples to be analyzed for cyanide will be checked in the field for the presence of chlorine using potassium iodide (KI) starch paper. If chlorine is present, ascorbic acid will be added until the KI paper indicates that no chlorine is present.

After the bottles for a given sample site have been filled, they will be placed in a shipping cooler. Field personnel will add bags of crushed ice or ice packs to the shipping coolers as the samples are collected. Each sample container will be cushioned with packing materials and sealed in a refrigerated cooler container for shipment to the laboratory by overnight delivery. Daily sample collection activities will be scheduled in order to assure overnight delivery of samples.

A chain-of-custody record will be prepared and will accompany all samples to provide documentation of all samples collected and to trace sample possession. Chain-of-custody procedures are discussed in detail in Section 5.5 of this document.

5.4.4 Field Quality Control (QC) Samples

Table 4-3 lists the percentage of field QC samples per sample matrix for the Level C and D analyses, based on current Navy (NEESA) guidance. A sampling event is defined as the time from which the sampling personnel arrive at the site until these personnel complete the sampling task. An example of two events would occur if sampling personnel went to a site for 3 weeks, drilled borings, and installed ground water monitoring wells. During this task, soil and water samples were collected for laboratory analysis. The sampling crew subsequently left the site for two months, thus concluding the first sampling event. The crew later returned to collect another set of ground water samples over a 3-day period. The second visit would constitute the second sampling event.

Trip blanks, rinsate blanks, and duplicate samples will be collected as part of each sampling event, in order to ascertain a measure of quality control during each sampling round. The following sections describe the purpose and usage of each of these types of samples.

5.4.4.1 Trip Blanks

Trip blanks are defined as samples which originate as analyte-free water which is placed in volatile organic vials and preserved with Hydrochloric acid (HCl) in the laboratory and shipped to the site in the sample cooler with sample containers. These vials are subsequently returned to the laboratory with samples for volatile organics analysis (VOA). One trip blank will accompany each cooler containing

samples to be analyzed for VOAs, and will be stored at the laboratory with the samples. Trip blanks will be analyzed in order to evaluate the effect of ambient site conditions and sample shipment on sample integrity, and to ensure proper sample container preparation and handling techniques. All trip blanks will be labeled according to the proper chain-of-custody procedures and will be analyzed for volatile organic compounds.

5.4.4.2 Rinsate Blanks

Rinsate blanks will be collected in order to determine the effectiveness of the decontamination of sample collection equipment. The rinsate blank will be collected by pouring laboratory-supplied, analyte-free deionized water for inorganic fraction analyses and HPLC-grade water for organic fraction analyses over the decontaminated sample collection equipment (i.e., bailer, stainless steel spoon, etc.) and into the appropriate sample containers. Rinsate blanks will be collected for each matrix sampled. All rinsate blanks will be analyzed for the same analytical parameters as the sample matrix. A minimum of one rinsate blank will be collected for every 20 samples or per day per matrix, whichever is greater. All field blanks will be preserved in accordance with the methods specified in Table 4-2, labeled according to the proper chain-of-custody procedures, and stored and shipped according to the procedures discussed previously.

5.4.4.3 Source Water Blanks (Field Blanks)

Source water blanks consist of the source water (obtained from NETC-Newport water supply) used for decontamination (e.g., steam cleaning). At a minimum, one source blank from each source of water will be collected and analyzed for the same parameters as the related samples. In addition, samples of the distilled water used in sampling equipment decontamination will also be analyzed for the full list of analytical parameters.

5.4.4.4 Field Duplicates

Duplicate samples will be collected, homogenized, and split. The procedure for collecting duplicate samples consists of alternating the collection of the sample between the sample collection bottle and the duplicate collection bottle. Samples for volatile organic compound analyses will not be mixed, but equal portions of the sample will be collected simultaneously and placed in 40-ml glass vials. Field duplicates will be collected at a frequency of 10 percent per sample matrix (NEESA - Level D). All duplicate samples will be sent as "blind" (unknown duplicate samples) to the primary laboratory responsible for the sample analysis.

5.4.4.5 Regulatory Splits

If regulatory agencies (state or federal) wish to obtain samples for independent analysis which are duplicates of those collected by HNUS, these regulatory split samples will be collected in the same manner as field duplicates. However, these splits will be sent by the regulatory agency to a separate, independent laboratory for analysis.

5.4.5 Field Decontamination Procedures

Drill rigs, backhoes, and drilling equipment will be decontaminated prior to moving to a site. Drilling equipment used for multiple boreholes will be decontaminated prior to each use. All decontamination of drill rigs and drilling equipment (e.g., augers, rods) will be conducted at designated decontamination areas with a steam cleaner. Decontamination of sampling equipment will be performed at designated decontamination areas. Sampling equipment such as split-spoons, stainless steel spoons or spatulas, and stainless steel mixing bowls will be decontaminated using the following procedures:

- Potable water rinse;
- Alconox or Liquinox detergent wash;
- Potable water rinse;
- Nitric acid rinse;
- Analyte free water rinse;
- Methanol rinse;
- Analyte free water rinse; and
- Air dry.

NOTE: Clean equipment may rest on -- but never be wrapped in clean polyethylene sheeting.

An attempt will be made to coordinate a drilling sequence hierarchy from less likely to more likely contaminated boring locations to reduce the potential for cross-contamination between locations. All sampling equipment will be decontaminated prior to use at each sampling location.

All decontamination rinsates will be collected and contained in drums for subsequent determination of proper handling and/or disposal.

5.5 SAMPLE CUSTODY

5.5.1 Introduction

Sample custody procedures will be observed to ensure the validity of the data generated during this program. Sample chain-of-custody will be initiated with selection and preparation of the sample containers. To reduce the chance for error, the number of personnel handling samples will be restricted, and one person will be assigned the responsibility of field sample custodian.

On-site monitoring data will be controlled and entered daily in permanent log books, as appropriate. Personnel involved with the sample chain-of-custody process will be trained in sample collection and handling procedures prior to project initiation.

5.5.2 Field Sample Custody

Sample custody and documentation procedures described in this section will be followed throughout all sample collection activities at NETC-Newport. Components of sample custody procedures include the use of field notebooks, sample labels, and chain-of-custody forms.

5.5.2.1 Field Notebooks

The HNUS project manager will oversee the maintenance of all field notebooks. Field notebooks will be bound books, preferably with consecutively numbered pages, that are at least 4 inches x 7 inches in size. Field notebooks will be maintained by the HNUS field team leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation activities. All notebook entries will be signed and dated.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include the following information (at a minimum):

- Name and address of field contact;
- Name and title of author, date and time of entry, and physical/ environmental conditions during field activity;
- Names of field crew;
- Names and titles of any site visitors;
- Type of sampling activity;
- Location of sampling activity;

- Description of sampling point(s);
- Date and time of sample collection;
- Sample media (e.g., soil, sediment, ground water, etc.);
- Sample collection method;
- Number and volume of sample(s) taken;
- Analyses to be performed;
- Sample preservatives;
- Sample identification number(s);
- Field observations;
- Any field measurements made such as pH, temperature, conductivity, water level, etc.;
- References for all maps and photographs of the sampling site(s); and

All original data recorded in either the field notebooks, on sample labels, or in the chain-of-custody records will be written with waterproof ink. None of these accountable, serialized documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by crossing a line through the error and entering the correct information and initialing the cross-out. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

The following Halliburton NUS Standard Operating Procedures which are included in Appendix C of this document, must be followed for sampling activities at NETC - Newport:

- GH-1.3, Section 5.0: Soil and Rock Sampling;
- GH-1.4, Section 5.0: Soil and Rock Drilling Methods;
- GH-1.5, Section 5.0: Borehole and Sample Logging;
- GH-1.6, Section 5.0: Decontamination of Drilling Rigs and Monitoring Well Materials;
- GH-1.7, Section 5.0: Groundwater Monitoring Point Installation;
- GH-1.8, Section 5.0: Excavation of Exploratory Test Pits and Trenches;
- GH-2.4, Section 5.0: In-Situ Hydraulic Conductivity Testing;
- GH-2.5, Section 5.0: Water Level Measurements/Contour Mapping;
- SA-1.1, Section 5.0: Groundwater Sample Acquisition;
- SA-1.2, Section 5.0: Surface Water and Sediment Sampling;
- SA-1.3, Section 5.0: Soil Sampling in Test Pits and Trenches;
- SA-6.1, Section 5.0: Sample Identification and Chain of Custody;

- SA-6.2, Section 5.0: Sample packaging and Shipping;
- SA-6.3, Section 5.0: Site Logbook;
- SF-1.1, Section 5.0: On-Site Water Quality Testing;
- SF-1.2, Section 5.0: Sample Preservation;
- SF-2.3, Section 5.0: Decontamination of Chemical Sampling and Field Analytical Equipment;
- ASTM D 1586-84, Section 7: Penetration Test and Split-Barrel Sampling of Soils

5.5.2.2 Sample Labels

All samples obtained at the site will be placed in an appropriate sample container for preservation prior to shipment to the laboratory. Each sample will be individually identified with a separate identification label recorded with a unique sample identifier. The information recorded on the label will include:

- Project name/project number/location;
- Sample identifier/number;
- Analysis to be performed;
- Preservatives used, especially any non-standard types, and any other field preparation of the sample;
- Date of collection;
- Time of collection (a four-digit number indicating the 24-hour (military) clock time of collection; e.g., 1430 for 2:30 p.m.);
- Number of containers per analyte (i.e., 1 of 2, etc.); and
- Sampler's initials.

Examples of HNUS's proposed sample identification labeling format for each sample type are presented in Section 4.3.

5.5.2.3 Custody Seals

Samples will be placed in sample coolers and the coolers will be sealed with custody seals prior to shipment to the laboratory. Clear adhesive tape will be placed over the seals to ensure that seals are not accidentally broken during shipment.

5.5.2.4 Chain-of-Custody Records

All samples will be accompanied by a chain-of-custody record, an example of which is included in Appendix G. A chain-of-custody record will accompany the sample from initial sample container selection and preparation commencing at the laboratory, to the field for sample containment and preservation, and through its return to the laboratory. If samples are split and sent to different laboratories, a copy of the chain-of-custody record will be sent with each sample.

The "Remarks" column in the chain-of-custody record will be used to record specific considerations associated with sample acquisition such as: sample type, container type, and sample preservation methods. When transferring samples, the individuals relinquishing and assuming sample custody will sign, date, and note the transfer time on the record.

A minimum of two copies of the chain-of-custody record will follow each sample to the laboratory. The laboratory will maintain one file copy, and the completed original will be returned to the HNUS Project Manager. A copy of the completed original will be returned as a part of the final analytical report. This record will be used to document sample custody transfer from the sampler, to another HNUS team member, to a shipper, or to the laboratory, and also to verify the date of sample receipt in the laboratory.

Shipments will be sent by overnight carrier with appropriate bill of lading documentation. Bills of lading will be retained as part of the permanent program documentation.

5.5.2.5 Sample Shipment

Samples will be delivered to the laboratory for analysis as soon as practical after the number of samples and sample containers is sufficient to comprise a shipment, preferably the same day the samples are collected. Sample shipment will occur at a minimum frequency of every other day. All samples will be stored in coolers at a temperature of 4°C. The samples will be accompanied by the chain-of-custody record. During sampling and sample shipment activities, the HNUS field team leader (or his designee) will contact the laboratory daily to provide information about impending shipments.

5.5.2.6 Sample Master Log Notebook

In addition to the field notebook documentation, all samples will be documented in a master sample log notebook for future reference. This master sample log will include the following information: sample identifier, sampling date and time (military), sampling personnel, matrix type (i.e., soil),

containers/parameters for analysis, date and method of shipment, any sample preservation, and any other pertinent information relating to the sample(s). The master sample log will be consistently updated during sampling activities in the field for review during field audits. Upon completion of sampling activities, the master sample log notebook will be delivered to the HNUS Project Manager.

5.5.3 Laboratory Sample Custody

The HNUS Field QC Coordinator will notify the laboratory of upcoming field sampling activities and subsequent sample transfer to the laboratory. This notification will include information concerning the number and type of samples to be shipped, as well as the anticipated sample arrival date.

The laboratory will designate a sample custodian who will be responsible for maintaining sample custody and for maintaining all associated custodial documentation records. After receiving the samples, the sample custodian will check the original chain-of-custody record and request for analysis documents against the labeled contents of each sample container for correctness and traceability. The sample custodian will then sign the chain-of-custody record and record the date and time that the sample shipment was received at the laboratory. The samples will then be logged into the laboratory system.

Care will be exercised in the laboratory to annotate any labeling or descriptive errors associated with the sample containers. In the event of discrepant documentation, the laboratory will immediately contact the HNUS QAM and project manager as part of the corrective action process. A qualitative assessment of each sample container will be performed to note any anomalies, such as broken or leaking bottles. This assessment will be recorded as part of the incoming chain-of-custody procedure.

Samples will be stored in a secured dark area and at a temperature of approximately 4°C, if necessary, until analyses are performed. A laboratory chain-of-custody record will accompany the sample or sample fraction through final analysis for sample control. A copy of the chain-of-custody record will accompany the laboratory's analytical report and will become a permanent part of the project's records. The pH of incoming water samples will be checked by the laboratory when preservatives have been added to the sample. Details of the chain-of-custody for laboratory activities will be provided in the laboratory's QA manual.

5.5.4 Evidence File

The HNUS Project Manager will serve as file custodian. At the project's completion, the files will be returned to the Navy's Northern Division Office where they will be permanently archived.

The evidence file will contain all incoming materials related to the project such as: sketches, correspondence, authorizations, and logs. These documents will be placed in the project file as soon as possible. If correspondence is needed for reference by project personnel, a copy will be made rather than manipulating the original. All records shall be legible and easily identifiable.

Examples of the types of records that will be maintained in the project file are:

- Field documents;
- Correspondence;
- Photographs;
- Laboratory data;
- Reports; and
- Subcontract agreements.

Out-going project correspondence and reports will be reviewed by the Project Manager or designee prior to mailing.

To prevent the inadvertent use of obsolete or superseded project-related procedures, all personnel of the laboratory and project staffs will be responsible for reporting changes in protocol to the Laboratory Project Manager and the Laboratory Director. The Laboratory Project Manager and Laboratory Director will then inform the project and laboratory staffs and the Quality Assurance Officer of these changes, as appropriate.

Revisions to procedures shall be subject to the same level of review and approval as the original document. Outdated procedures shall be marked "void". The voided document may be destroyed at the request of the Laboratory Project Manager; however, it is recommended that one copy of the voided document be maintained in the project file. The date and reason why the document was voided will be recorded.

5.6 CALIBRATION PROCEDURES AND FREQUENCY

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the instrument manufacturer's specifications and appropriate HNUS Standard Operating Procedures.

Laboratory instrumentation calibration procedures and frequencies are specified in the Contract Laboratory Program (CLP) Statement of Work (SOW), for Organic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; revised July 1991 and in the CLP SOW for Inorganic Analysis; Multi-Media, Multi-Concentration; SOW No. 3/90; September 1991, and will be strictly followed for those analytes analyzed by CLP protocols. For all other analyses for which EPA-approved methods exist, the laboratory will employ such methods and follow the specified calibration procedures and frequencies. The laboratory quality control program includes strict adherence to routine calibration procedures. A description of calibration procedures and frequencies for non-CLP methods will be provided by the laboratory selected for this program.

Analysis of blank samples, duplicate samples, spiked blanks, and matrix blanks will be performed where possible to document the effectiveness of calibration procedures. Method blanks contain all the reagents used in the preparation and analysis of the samples and are processed through the entire analytical scheme to assess spurious contamination from reagents, glassware and other materials used during analysis. The terms method blank and laboratory blank are interchangeable. A matrix blank denotes a blank of a similar matrix (e.g., for liquids a blank of distilled-deionized reagent grade high purity water may be used; for soils/sediments high purity sand may be used). A blank spike is a method blank which has had a known concentration of a particular compound or analyte added to it to assure adequate percent recovery of the compound/analyte.

Records of calibration, repair, or replacement will be maintained by the designated laboratory personnel performing quality control activities. Calibration records of assigned laboratories will be filed and maintained at the laboratory location where the work is performed and subject to QA audit.

Calibration of field instruments will be performed at approved intervals as specified by the manufacturer or more frequently, as conditions dictate. At a minimum all field instruments will be calibrated at the beginning and end of each day. Calibrations may also be performed at the start and completion of each test run; however, such calibrations will be re-initiated as a result of delay due to meals, work shift change, or instrument damage. Calibration standards used as reference standards will be traceable to the National Bureau of Standards (NBS), when possible. Calibration procedures for field instruments will be as specified by the instrument manufacturer. Equipment manuals describing calibration procedures will be maintained in the field office during site investigations.

5.7 ANALYTICAL PROCEDURES

5.7.1 Introduction

EPA-approved methods will be used for all analyses for which such methods exist. Target Compound List (TCL) and Target Analyte List (TAL) parameters will be analyzed by Contract Laboratory Program (CLP) protocols. The laboratory will follow methods detailed in the CLP Statement of Work (SOW) for Organic Analyses, Multi-media, Multi-concentration, 3/90, revised July 1991, and the SOW for Inorganics Analyses, Multi-media, Multi-concentration, 3/90, revised September, 1991. US Navy NEESA guidance for Level D analyses will also be adhered to by the laboratory when more stringent than the CLP requirements.

If sample contaminant concentrations are high, then CLP protocols for low and medium concentration samples may be required. In this case, sample runs at lower dilutions will be performed to obtain quantitative results for parameters present at lower concentrations. That is, samples are pre-screened to estimate concentration levels. According to EPA methodology, high concentration samples are diluted to bring them within a linear working range. Low concentration samples are set aside and then analyzed within the same linear working range. It may not be possible to quantitate sample results in parts per billion for samples where "pure" waste (fuel product, paint, powder, etc.) is encountered. A decision tree approach will be followed, in order to quantitate the sample when high levels of contamination are encountered. In this case, detection limits will be raised for all analytes on the sample, as the sample is diluted.

5.7.2 Target Compound List - Organic Compounds

All organic compound analyses will be conducted according to the U.S. EPA CLP, Statement of Work for Organic Analyses, SOW 3/90, revised August 1991. The organic compounds contained in the TCL will be determined using proven methods to identify and quantify volatile, semi-volatile and pesticide/PCB compounds. The actual detection limits obtainable for a specific sample depend upon matrix interferences. If the CLP detection limit is unachievable for a particular sample, an explanation of the problem and supporting evidence will be provided by the laboratory in the case narrative summary submitted with the deliverables.

Each set of samples will be analyzed in conjunction with the analysis of QC samples, including field duplicates, blanks, matrix spikes and matrix spike duplicate (MS/MSD) samples for quality control determinations. The frequency of analysis of the QC samples, as previously presented in Section 5.4.4, will not be less than one per 20 samples and at least one per sampling day for rinsate blanks,

not less than one per 10 samples for field duplicates, and not less than one per 20 samples for MS/MSD samples. All samples, field duplicates, blanks, matrix spike and matrix spike duplicates will be fortified with surrogate spiking compounds. The percentage recovery of the matrix spiking compounds and relative percentage difference of duplicate analyses will be calculated to obtain measurements of the analyses accuracy and precision.

5.7.3 Target Analyte List - Metals

All water and soil samples will be prepared for analyses as described by procedures for each respective matrix and analysis method described in the U.S. EPA CLP, Statement of Work for Inorganic Analyses (SOW 3/90). Each set of samples, or 20 samples, whichever is more frequent, will be analyzed with a preparation blank, duplicate sample, and matrix spiked sample. Each group of 20 samples will be analyzed with a laboratory control sample of similar matrix.

The atomic absorption (AA) instrument will be calibrated through the use of a minimum of three calibration standards prepared by dilution of certified stock solutions. Calibration standards will contain acid(s) at the same concentration as the digestates. An analysis blank will then be prepared, and one calibration standard will be at the EPA-CLP required detection limit for the metal being evaluated. The other standard concentrations will bracket the concentration range of the samples. A continuing calibration standard, prepared from a different stock solution than that used for the calibration standards, will be prepared and analyzed after every ten samples or every two hours of continuous instrument operation. The value of the continuing calibration standard concentration must agree with requirements of the CLP SOW.

5.7.4 Miscellaneous Parameters

All water and soil samples analyzed for the various miscellaneous parameters (TOC, CEC, grain size distribution, total chloride, BOD, COD, TSS, acid volatile sulfides, and simultaneously extractable metals) will be prepared and analyzed by the required EPA and Standard Methods listed in Table 4-1. The appropriate quality control samples and calibration frequencies described in each analytical method shall be followed. The method detection limits and/or practical quantitation limits in each analytical method should be referenced.

5.8 DATA REDUCTION, VALIDATION, AND REPORTING

5.8.1 Introduction

The procedures used for calculations and data reduction are specified in each analytical method referenced in Section 5.7 of this document. Raw data will be entered in bound laboratory notebooks. A separate book will be maintained for each analytical procedure. The data will be entered such that sufficient space remains to enter all subsequent calculations required to arrive at the final (reported) value for each sample. Calculations include factors such as sample dilution ratios, corrections for titrant normality, and conversion to dry-weight basis for solid samples. Instrument chart recordings and calculator printouts will be labeled and attached to their respective pages, except for voluminous gas chromatograms which will be cross-referenced and stored separately.

Calculations will be checked from the raw data to final value stages prior to reporting the results for a group of samples. Results obtained from extreme ends of standard curves generated by linear regression calculator programs will be checked against graphically-produced standard curves if the correlation coefficient of a program curve is less than 0.995.

Data will generally be reported as micrograms of analyte per liter for aqueous samples or micrograms per kilogram (dry weight) for solid or non-aqueous liquid samples. Concentration units will always be listed on reports and any special conditions, such as dry weight conversions, will be noted. The data reporting form will also include the unique sample number assigned to each sample, details of sample collection including the client's identification number, and the dates of sample receipt and report preparation.

5.8.2 Data Reduction

5.8.2.1 Target Compound List Compounds

Instrument performance test data will accompany the raw data during data reduction. The following criteria must be attained to make a qualitative identification of an organic pollutant using Gas Chromatograph/Mass Spectrometer (GC/MS) techniques:

- Characteristic ions for each compound of interest must maximize in the same or within one scan of each other.

- Retention time must occur within ± 1 percent of the retention time of the authentic compound.

- Relative peak heights of the three characteristic ions in the Extracted Ion Current Profile (EICP) must fall within $\pm$ 20 percent of the relative intensities of these ions in a reference mass spectrum. The reference mass spectrum can be obtained by a standard analyzed in the GC/MS system or from a reference library.

- The entire mass spectrum of the compound of interest is compared to the reference compound.

Structural isomers having similar mass spectra can be explicitly identified only if the resolution between authentic isomers in a standard mix is acceptable. Acceptable resolution is achieved if the baseline-to-valley height between the isomers is less than 25 percent of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

When a compound has been identified, the quantitation of that compound is based on the integrated abundance from the EICP of the primary characteristic ion. The base peak ion of internal and surrogate standards is used in the quantitation. If the sample produces an interference for the first listed ion, a secondary ion is used to quantitate. Quantification is performed using internal standard techniques.

To ensure that reported data are accurate, all resultant data are verified. Retention items and area counts are checked carefully for correct identification and accurate quantification.

5.8.2.2 Metals and Cyanide

The concentrations of metals determined by Atomic Absorption Spectroscopy (AAS) measurements are obtained by comparison of absorbance values with those obtained from the analyses of known standards. A linear regression plot of absorbance versus concentration will be used to determine a concentration factor for linearity of response.

In the event of low (<85%) or high (>115%) post-digestion spike recovery, the analysis will be repeated using the method of known additions to determine potential matrix interferences. CLP criteria will be maintained for analyses of samples of similar matrix. The mean percentage recovery and standard deviation will be calculated from a minimum of 20 analyses. A warning limit of ± 2 standard deviations from the mean and a control limit of ± 3 standard deviations will be used to establish that the test is providing accurate data.

5.8.3 Data Validation

Data validation is the process of reviewing data and associated quality control criteria and accepting, qualifying, or rejecting it on the basis of sound criteria. Project supervisory and QC personnel will use validation methods and criteria appropriate to the type of data and the purpose of the measurement. Records of all data will be maintained, even that judged to be an "outlying" or anomalous value. The HNUS personnel validating the data will have sufficient knowledge of the technical work to identify questionable values.

5.8.3.1 Field Data Validation

Field sampling data will be validated by the HNUS Field QC Coordinator or QA/QC Manager, based on their judgment of the representativeness of the sample, maintenance and cleanliness of sampling equipment, and adherence to the approved, written sample collection procedure.

The following criteria will be used to evaluate the field sampling data:

- Use of approved sampling procedures;
- Use of reagents/standards that conform to QC-specified criteria; and
- Proper chain-of-custody maintained and documented.

5.8.3.2 Analytical Data Validation

Analytical data validation will include validation procedures within the laboratory and independent of the laboratory.

Data from laboratory analyses will be validated by the Laboratory QC Coordinator using criteria outlined below. Results from field and laboratory method blanks, replicate samples, equipment rinsates and internal QC samples will be used to validate analytical results.

The criteria listed below will be used to evaluate the analytical data:

- Use of approved analytical procedures;
- Use of properly operating and calibrated instrumentation;

- Acceptable results from analyses of laboratory control samples (i.e., the reported values should fall within the 95 percent confidence interval for these samples); and

- Precision and accuracy for this project should be comparable to that achieved in previous analytical programs and consistent with objectives stated in Section 7 of this QAPP.

Independent of the analytical laboratory, analytical data validation will be conducted which will follow the most stringent of the requirements and protocols specified in the following documents:

U.S. EPA, "Region I Laboratory Data Validation: Functional Guidelines for Evaluating Organic Analyses", February 1988; modified November 1988;

U.S. EPA, "Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses", June 1988, modified February 1989;

U.S. EPA, Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 3/90, revised August 1991;

U.S. EPA, Contract Laboratory Program, Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration, 3/90, revised September 1991; and

U.S. Navy/NEESA, *Sampling and Chemical Analysis Quality Assurance Requirements for the* Navy Installation Restoration Program (NEESA 20.2-047B), June 1988.

All of the Phase II RI data will be validated in accordance with these requirements.

The data validation activities focus on areas of the analytical process which are under the laboratory's control when analyzing samples. The data qualifiers which result from validation represent the QC areas under the laboratory's control which could have been improved. Qualifiers attached to the data during validation supersede the qualifiers assigned by the laboratory.

Areas reviewed in the validation of organic data include the following: sample holding times, gas chromatography/mass spectroscopy (GC/MS) tuning, instrument calibration, blank analysis, surrogate recovery, matrix spike/matrix spike duplicates, internal standards (IS) performance, Target Compound List (TCL) compound identification, compound quantitation and reported detection limits, tentatively identified compounds, system performance, and overall assessment of the data for usability.

The areas reviewed in the validation of inorganic data include the following: sample holding times, instrument calibration and initial calibration verification, continuing calibration verification, Contract Required Detection Limit (CRDL) standards for Atomic Absorption (AA) and Inductively Coupled Plasma (ICP) spectrometers, initial and continuing calibration blank analysis, ICP interference check sample analysis, spiked sample analysis, post digested spike sample recovery analysis, duplicate sample analysis, laboratory control sample analysis, ICP serial dilution analysis, graphite furnace AA QC analysis, quarterly verification of instrument parameter report, and sample result verification.

5.8.4 Identification and Treatment of Outliers

Any data point which deviates markedly from others in its set of measurements will be investigated; however, the suspected outlier will be recorded and retained in the data set. The following tests will be used to identify outliers.

Dixon's test for extreme observations is an easily computed procedure for determining whether a single very large or very small value is consistent with the remaining data. The one-tailed t-test for difference may also be used in this case. It should be noted that these tests are designed for testing a single value. If more than one outlier is suspected in the same data set, other statistical methods, such as analysis of variance, tolerance intervals, or control charts, will be considered and the most appropriate method will be used and documented.

Since an outlier may result from unique circumstances at the time of sample analysis or data collection, those persons involved in the analysis and data reduction will be consulted. This may provide information on an experimental reason for the outlier. Further statistical analysis will be performed with and without the outlier to determine its effect on the conclusions. In many cases, two data sets will be reported, one including and one excluding the outlier.

In summary, every effort will be made to include the outlying values in the reported data. If the value is rejected, it will be identified as an outlier, reported with its data set and its omission noted.

5.8.5 Analytical Deliverables

Analytical deliverables will meet the requirements of the USEPA CLP SOW for Organic Analysis; Multi-Media, Multi-Concentration, 3/90, revised July 1991, and the USEPA CLP SOW for Inorganic Analysis, Multi-Media, Multi-Concentration, 3/90, revised September 1991.

5.9 INTERNAL QUALITY CONTROL CHECKS AND FREQUENCY

5.9.1 Introduction

Quality control checks will be performed to ensure the collection of representative samples and the generation of valid analytical results on these samples. These checks will be performed by project participants through the program under the guidance of the HNUS CLEAN QAM.

5.9.2 Data Collection and Sampling QC Procedures

The HNUS internal QC checks for the sampling aspects of this program will include, but not be limited to, the following:

- Use of field notebooks to ensure completeness, traceability, and comparability of the samples collected.
- Field checking of field notebooks and sample labels by a second person to ensure accuracy and completeness.
- Strict adherence to the sample chain-of-custody procedures outlined in Section 5 of this document.
- Collection and analysis of trip blanks, source blanks, field blanks, and field duplicates.
- Calibration of the field monitoring equipment (e.g., HNU, OVA), as described in Section 6.0 of this document.

5.9.3 Analytical QC Procedures

5.9.3.1 Trip Blank Analysis

Volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the Teflon-faced silicone rubber septum of the sample vial. Therefore, trip blanks will be analyzed to monitor for possible sample contamination during shipment. Trip blanks will be prepared by filling two volatile vials with laboratory-supplied, organic-free water which then will be shipped with the field sampling kit. Trip blanks will be preserved by the laboratory with hydrochloric acid. Trip blanks accompany the sample bottles through collection and shipment to the laboratory and are stored with

the samples. Following the analyses, if the trip blanks indicate possible contamination of the samples, depending upon the nature and extent of the contamination, the sample results will be qualified with respect to the contamination detected in the trip blanks. Results of trip blank analyses will be maintained with the corresponding sample analyses data in the project file.

5.9.3.2 Reagent Blank Analysis

A reagent blank is a volume of deionized, distilled laboratory water carried through the entire analytical procedure. The volume of the blank must be approximately equal to the sample volume processed. A reagent blank should be performed with each group of samples. Analysis of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized. Optimally, a reagent blank should meet CLP criteria. Results of reagent blank analyses will be maintained with the corresponding analytical data in the project file.

5.9.3.3 Duplicate Sample Analysis

Duplicate analyses are performed to evaluate the precision of an analysis. Results of the duplicate analyses are used to determine the relative percent differences between duplicate samples. Field (blind) duplicate samples will be collected for each media sampled at a frequency of one per ten samples collected. Duplicate analysis results will be reported together in the final RI report.

5.9.3.4 Verification/Reference Standard

On a quarterly basis, the laboratory Quality Control Coordinator introduces a group of prepared verification samples, or standard reference materials, into the analytical testing regime. The laboratory checks and approves the purity of standards and reagents prior to use. Results of the verification/reference standard data will be summarized, evaluated, and presented to laboratory management for review and corrective actions, if appropriate.

5.9.3.5 Other Laboratory Quality Control Checks

Quality control checks will be performed to ensure the collection of representative samples and the generation of valid analytical results on these samples. These checks are performed by project participants under the guidance of QC personnel.

The laboratory will make use of various types of QC samples to document the validity of the generated data. The following types of QC samples are routinely used:

Calibration Check Samples--One of the working calibration standards which is periodically used to check that the original calibration is still valid.

Spiked Samples--Replicate aliquots of project samples are spiked with components of interest and carried through the entire preparative and analytical scheme.

Laboratory Control Samples (LCS)--These samples are prepared from EPA Environmental Monitoring Systems Laboratory (EMSL) concentrates or National Bureau of Standards (NBS) standard reference materials. The LCS are used to establish that an instrument or procedure is in control. An LCS is normally carried through the entire sample preparation and analysis procedure.

Surrogate Spikes--Samples requiring analysis by GC and GC/MS are routinely surrogate-spiked with a series of deuterated analogues of the components of interest. It is anticipated that these compounds would assess the behavior of actual components in individual program samples during the entire preparation and analysis scheme.

Matrix Spikes/Matrix Spike Duplicates (MS/MSD)--One MS/MSD pair will be run per 20 samples for each different matrix analyzed. These pairs will be spiked with the target compounds of concern for that matrix.

All values which fall outside the QC limits described in the analytical method will be noted. The following analytical guidelines will be used to check recovery values which fall outside the QC limits:

1. All recovery data are evaluated to determine if the QC limits are appropriate and if a problem may exist even though the limits are being achieved (e.g., one compound that is consistently barely within the lower limit).

2. All recovery data which are outside the established limits are evaluated. This evaluation includes an independent check of the calculation.

3. Corrective action is performed if any of the following are observed:

- All recovery values in any one analysis are outside the established limits.
- Over 50 percent of the values for a given sample set are outside limits.
- One compound is outside the limits in over 50 percent of the samples.

Reagents used in the laboratory are normally of analytical reagent grade or higher purity. Each lot of acid or solvent used is checked for acceptability prior to laboratory use. All reagents are labeled with the date received and date opened. All glassware is precleaned according to specifications contained in the analytical method. Standard laboratory practices for laboratory cleanliness, personnel training, and other general procedures are used.

5.9.3.6 Laboratory Control Charts

The control chart displays data in a format which graphically compares the variability of all test results with the average or expected variability of small groups of data. The variability may be due to random (indeterminate) or assignable (determinate) causes. The control chart distinguishes indeterminate from determinate variation in a process or method by its control limits. If a value falls outside the control limits, it is considered out-of-control, almost certainly due to a determinate cause which has been added to the indeterminate variations. The control chart signals the need to investigate, find the determinate cause, and correct it. Construction of a control chart requires a minimum of 14 to 20 duplicate sets of data points (which limits its use).

QC samples and instrument calibrations lend themselves most readily to the gathering of the data. Calculation of control limits and the values are usually plotted chronologically so that trends or cycles can be readily detected. If QC sample measurements show an out-of-control condition, it can be expected that subsequent sample analyses might yield invalid data. The control chart is an effective indicator of the need for corrective action.

For volatile and semi-volatile organics and pesticide analyses performed by GC/MS, surrogate recoveries from the method blank are the control sample. For other organics (e.g., PCBs, dioxins/furans), an LCS (spiked blank) is used to plot the control charts. An LCS is also used as the control point for inorganic analyses.

5.10 PREVENTIVE MAINTENANCE

5.10.1 Preventive Maintenance Procedures

Field equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations and written procedure developed by the operators.

The laboratory will follow an orderly program of positive actions to prevent the failure of laboratory equipment or instruments during use. This preventive maintenance and careful calibration helps to assure accurate measurements from instrumentation. Routine maintenance procedures are followed for all instruments, glassware, reagents, analytical balances, and equipment used to produce deionized water. Specific procedures will be outlined in the laboratory Standard Operating Procedures (SOPs).

5.10.2 Schedules

Manufacturer's procedures identify the schedule for servicing critical items in order to minimize the downtime of the measurement system. It will be the responsibility of the operator to adhere to this maintenance schedule and to arrange any necessary and prompt service as required. Service to the equipment, instruments, tools, gauges, etc., shall be performed by qualified personnel.

In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based upon experience and previous use of the equipment.

5.10.3 Records

Logs are maintained to record maintenance and service procedures and schedules. All maintenance records will be documented and traceable to the specific equipment, instruments, tools and gauges. Records produced shall be reviewed, maintained, and filed by the operators at the laboratories and by the data and sample control personnel when and if equipment, instruments, tools and gauges are used at the site. The project QA officer may audit these records to verify complete adherence to these procedures.

5.10.4 Spare Parts

Critical spare parts are maintained by HNUS and the laboratory for field and analytical equipment, respectively. These spare parts will be stored for availability and used in order to reduce equipment downtime.

5.11 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

5.11.1 Introduction

Procedures used to assess data precision and accuracy will be in accordance with 44 FR 69533 "Guidelines Establishing Test Procedures for the Analyses of Pollutants", Appendix III Example Quality Assurance and Quality Control Procedures for Organic Priority Pollutants", December 3, 1979. Completeness is recorded by comparing the number of parameters initially analyzed with the number of parameters successfully completed and validated. For this project, a target control limit of greater than 90 percent will be used.

5.11.2 Accuracy

The percent recovery is calculated as:

$$\% = \frac{S_o - S_s}{S} \times 100$$

where: So = The background value, i.e., the value obtained by analyzing the sample.

S = Concentration of the spike added to the sample.

Ss = Value obtained by analyzing the sample with the spike added.

% = Percent recovery.

5.11.3 Precision

The relative percent difference is calculated as:

$$1/2 \times \frac{(V_1 - V_2)}{(V_1 + V_2)} \times 100 = \% \text{ difference}$$

where: V1,V2 = The two values obtained by analyzing the duplicate samples.

5.11.4 Completeness

Completeness will be reported as the percentage of all measurements made whose results are judged to be valid. The procedures to be used for validating data and determination of outliers are contained in Section 5.8. of this document. The following formula will be used to estimate completeness:

$$C = 100 \times \frac{V}{T}$$

where: C = Percent completeness.

V = Number of measurements judged valid.

T = Total number of measurements.

5.12 CORRECTIVE ACTION

5.12.1 Introduction

The acceptance limits for the sampling and analyses under this program will be those stated in the method or defined by other means in the QAPP. Corrective actions are often immediate in nature, implemented by the analyst or Project Manager. The corrective action usually involves recalculation, reanalysis, or repeating sample collection.

5.12.2 Immediate Corrective Action

If an immediate corrective action can be taken as part of normal operating procedures, the collection of poor quality data can be avoided. Instrument and equipment malfunctions are amenable to this type of action. QC procedures include troubleshooting guides and corrective action suggestions. The

actions taken will be noted in field or laboratory notebooks, but no other formal documentation is required, unless further corrective action is necessary. These on-the-spot corrective actions are an everyday part of the QA/QC system.

Corrective action during the field sampling portion of a program is most often a result of equipment failure or an operator oversight and may require repeating a sampling run. Operator oversight is best avoided by having field crew members audit each others' work before and after a test. Every effort will be made by the field team leader to ensure that all QC procedures are followed. If potential problems are not solved as an immediate corrective action, HNUS will apply formalized long-term corrective action, if necessary.

Corrective action for analytical work will include recalibration of instruments, reanalysis of known QC samples and, if necessary, reanalysis of actual field samples. Specific QC procedures and checklists are used by the laboratory to help analysts detect the need for corrective action. Often the person's experience will be valuable in alerting the operator to suspicious data or malfunctioning equipment.

5.12.3 Long-Term Corrective Action

The need for long-term corrective action may be identified by standard QC procedures, control charts, performance or system audits. Any quality problem which cannot be solved by immediate corrective action falls into the long-term category. The HNUS QA system ensures that the quality problem is reported to a person responsible for correcting it, and who is part of a closed-loop action and follow-up plan.

The essential steps in the closed-loop corrective action system are listed below:

- Identify and define the problem;
- Assign responsibility for investigating the problem;

- Investigate and determine the cause of the problem;
- Determine a corrective action to eliminate the problem;
- Assign and accept responsibility for implementing the corrective action;
- Establish effectiveness of the corrective action and implement it; and
- Verify that the corrective action has eliminated the problem.

Documentation of the problem is important to the system. A Corrective Action Request Form (Figure 3) is filled out by the person finding the quality problem. This form identifies the problem, possible causes, and the person responsible for action on the problem. The responsible person may be an analyst, field team leader, QC coordinator, or the QA Officer. If no person is identified as responsible for action, the QA Officer investigates the situation and determines who is responsible in each case.

The Corrective Action Request Form includes a description of the corrective action planned and the date it was taken, and space for follow-up. The QAM checks to be sure that initial action has been taken and appears effective and, at an appropriate later date, checks again to see if the problem has been fully solved. The QAM receives a copy of all Corrective Action Forms and enters them in the Corrective Action Log. This permanent record aids the QA Officer in follow-up and makes any quality problems visible to management. The log may also prove valuable in listing a similar problem and its solution.

5.12.4 Out-of-Control Events and Corrective Action

Procedures are outlined as to what corrective action is taken if an out-of-control event occurs, and how it is documented and used to improve laboratory performance. Procedures for assuring that results for samples processed during out-of-control conditions are not reported are also outlined, as well as the conditions necessary to reestablish control and criteria for assuring the system is operating properly. The documentation is easily used by all personnel and is part of routine laboratory procedure.

It is recognized that several levels of out-of-control events may occur. Three examples are given below with corrective actions to be taken:

1. Observations Corrected by Analyst at the Bench--The calibration of an instrument is not linear. The analyst finds this and corrects it prior to continuing to analyze samples. The laboratory documents this event and notes that the corrective action was to

recalibrate, and that no samples were affected as none were analyzed prior to calibration.

2. Corrective Actions Taken by Supervisor--A matrix spike recovery is out-of-control and the laboratory supervisor finds this after the samples for the day have been analyzed. The supervisor documents that the laboratory blank spiked with surrogates or standards was in control and that other sample spikes were in control, therefore, no re-analysis of the sample is required.

3. Corrective Actions at the Receiving Level--The sample container is broken. The analyst notes this and documents whether or not more sample is available. If no more sample is available, HNUS is notified and the decision documented.

5.13 QUALITY ASSURANCE REPORTS TO MANAGEMENT

5.13.1 Internal HNUS Reports

The Project QC Coordinator will provide monthly reports of QC activities for the HNUS QA Officer and QA/QC Manager. These reports detail the results of quality control analysis, problems encountered, and any corrective action required.

All Corrective Action Forms will be submitted to the HNUS QA Officer for initial approval of the corrective action planned. A copy will be provided to the appropriate technical division manager. All system audit reports will be provided to the Program Manager and Project Manager.

5.13.2 Laboratory Reports

The laboratory QC Coordinator prepares written quarterly reports on QC activities for the laboratory Technical Director and QA Manager. These reports detail the results of QA procedures, problems encountered, and any corrective action which may have been required. All Corrective Action forms are submitted to the QA Manager for initial approval of the planned corrective action, and a copy is provided to the Technical Director. All system audit reports are provided to the Technical Director.

Each data transmittal contains a summary of QA/QC activities; this summary will include:

- Estimates of precision, accuracy and completeness of data;
- Reports of performance and system audits;

- Quality problems found; and
- Corrective actions taken.

The final data report submitted to HNUS by the laboratory will include a summary of QA/QC activities during the project. The QC Coordinator and QA Manager will participate in preparing this report. The summary of QA/QC results for the analytical work conducted for the NETC-Newport project will be included in the final RI Report.

5.13.3 Reports to the U.S. Navy Northern Division

The status of on-going laboratory QA/QC activity will be presented in the project progress reports. Monthly progress reports will be sent from the laboratory to the Navy's Engineer-In-Charge and NEESA QA/QC contract representative, as required. The final RI report for the project will include a section summarizing the significant findings of all QA/QC laboratory activity.

6.0 DATA EVALUATION AND ASSESSMENT PLAN

6.1 INTRODUCTION

Data evaluation and assessment describes the process of characterizing the site based on background investigations, site observations, and field investigations. The objective of this task is to define the nature and extent of contamination, and identify and evaluate potential chemical transport mechanisms and the environmental fate of identified contaminants, thereby providing the basis for human health risk assessments. Data management and reporting activities are key to conducting the site characterization activities.

6.2 DATA MANAGEMENT PLAN

Data management activities include field sampling documentation, sample management and tracking, analytical reporting, and document control.

6.2.1 Field Data Collection and Recording

During field sampling, consistent documentation and accurate recordkeeping procedures are critical. Data management procedures for field sampling at Melville North Landfill Site during Phase II investigations will include the following:

Quality Assurance Project Plan (QAPP) - Provides procedures and protocols for records responsibility, nonconformity event, corrective measure; and data deficiencies. The QAPP for Melville North Landfill appears in Section 5.0 of this Work Plan.

Data Security System and Chain-of-Custody - Describes strict chain-of-custody procedures that will be followed in the field and through sample analysis at the laboratory. Chain-of-custody records and shipping air bills will be maintained in a locked file cabinet at the HNUS field office at NETC-Newport. At the completion of field work, chain-of-custody records will be transferred to the central project file at the HNUS Wilmington, Massachusetts office.

Field Notebooks - Maintained by field personnel as the primary record for field investigation activities, as described in Section 5.0. Detailed descriptions of the information to be recorded in the field notebooks during site investigation activities as well as presentation of information

(including correction of errors) and management of the notebooks are provided in Sections 4.2.6.3 and 5.5.

Driller Logs - Maintained by the drilling contractor and HNUS geologist under direction of the HNUS Field Operations Leader to document boring and well construction logs.

6.2.2 Sample Management and Tracking

The HNUS Project Manager will maintain records of: sample shipments; analytical results receipt; preliminary results for QA/QC review submittal; QA/QC review results; and laboratory QC package evaluation. The objective is to ensure that only validated data with final approval are used in site analysis.

Preliminary data, clearly identified as such, may be used to prepare internal review documents; to begin data analysis, and to narrow remedial action alternatives. The final Remedial Investigation report, however, will clearly identify all validated data and will be accompanied by a QA/QC discussion and associated data qualifiers.

6.2.2.1 Sample Identification and Chain-of-Custody

The Field QC Coordinator will coordinate sample analysis with the laboratory. HNUS and the laboratory will use standard chain-of-custody procedures for sample tracking, which have been approved by EPA (CLP) and the Navy (NEESA). Chain-of-custody procedures are initiated in the laboratory upon sample container shipment to the field and continue with the return shipment of the samples to the laboratory. At the laboratory, a sample custodian continues the chain of custody by assigning a laboratory identification number to each sample. This identification number, along with the number assigned in the field, accompanies the sample through analysis, and back to the HNUS Project Manager with the analytical results. Chain-of-custody procedures are described in further detail in Section 5.0 of this Work Plan.

6.2.2.2 Reporting of Analytical Results

Data reporting procedures are described in the CLP analytical Statements of Work (as referenced in the QAPP), in the laboratory's NEESA-approved QA Manual, and in the QAPP prepared for this project. These procedures yield analytical data in a defined deliverable format. Laboratory data reporting procedures are briefly outlined below.

Manual Recording - The laboratory's Standard Operating Procedures and CLP protocol describe the QC procedures used for laboratory notebooks and include data worksheets that are routinely used in the reduction of quantitative instrument data to a report format. Instrumental data are entered on summary worksheets using microcomputers and appropriate software.

Automated Recording - Many analytical measurements at CLP laboratories are automatically recorded; e.g., complex analytical instruments have their own computerized data systems. Instrument checklists include checks on the operation of these data handlers and internal validity checks are used to flag data resulting from electronic interferences.

Calculation of Results - Whenever possible, laboratory calculations are computerized for efficiency and to avoid human error. The analytical data systems mentioned above calculate results as programmed and provide hard copy in the desired format. Computerized data are verified for error control, and careful handling of computer storage peripherals is stressed. Tests are built into the programs to trap transcription errors or missing items. The record of the run contains the calculation results, and the input data. Analytical results are reduced to the correct number of significant figures for the measurement technique.

Data Review - Acceptance limits are provided to help the operator spot questionable data and control charts are used whenever possible to show if the procedure is in control. The laboratory Quality Control Coordinator initiates control charts for instrument performance and specific analytical methods, and reviews routine and specialized QC sample results as they pertain to each project. In the laboratory, data are reviewed promptly to ensure reasonableness and determine if corrective action is needed.

Data Validation - Data validation is the process of reviewing data and accepting, qualifying, or rejecting it on the basis of sound criteria. A detailed discussion of data validation procedures is provided in Section 8.0 of the QAPP.

6.2.3 Document Control

A document inventory and filing system has been established for the NETC Newport RI/FS and will be maintained during Phase II Melville North Landfill site investigations. The HNUS Project Manager will be responsible for document control. All originals will be maintained in the central file. Project staff will make copies of documents, as needed, and return the originals. The file will be able to be locked during non-business hours.

6.3 REMEDIAL INVESTIGATION REPORT

Preparation of the Remedial Investigation Report involves evaluating of analytical data on existing site conditions (geology, hydrogeology), previous investigation data, and background information. This evaluation provides the basis for the determining the nature and extent of contamination at a given site as well as for the contaminant fate and transport analyses. The RI Report will present and assess both Phase I and Phase II RI data.

Initially, a draft RI report will be prepared and submitted for review. After response to review comments and approval, the final RI report will be prepared and submitted. A description of the outline of the Remedial Investigation Report is provided below and an outline of the report format is presented in Table 6-1.

6.4 FEASIBILITY STUDY REPORT

A report will be prepared presenting the results of the Feasibility Study. The FS Report will discuss site-specific remedial action objectives and general response actions, technologies screening and selection, and remedial alternatives formulation. Each alternative will be described along with a detailed analysis of how each addresses the nine evaluation criteria.

The alternative description shall provide data on technology components, quantities of hazardous materials to be handled, time required for implementation, process sizing, implementation requirements, and assumptions. The discussion of the detailed analysis will present the assessment of how each alternative addresses the evaluation criteria. Uncertainties associated with each alternative will also be identified as they may affect the analysis.

The report will also provide a comparative evaluation of all alternatives in a summary table which highlights findings from the detailed analysis. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative and to identify key tradeoffs to be evaluated by EPA.

A draft FS report will be prepared and submitted for review. After response to review comments and approval, the final FS report will be prepared and submitted. A description of the outline of the Remedial Investigation Report is provided below and an outline of the report format is presented in Table 6-2.

7.0 RISK ASSESSMENT

7.1 OBJECTIVES

The objectives of a risk assessment are to evaluate chemicals detected in an environmental medium, identify exposure routes and potential receptors, compile and present applicable toxicological and regulatory criteria, and to determine risk levels associated with identified exposure routes. The risk assessment process is comprised of the following elements: data evaluation, exposure assessment, toxicity assessment, and risk characterization, each being discussed in detail in the following subsections.

Current U.S. EPA agency-wide and Region I guidance for the performance of quantitative human health risk assessments will be followed. Specific guidance to be used includes:

- Risk Assessment Guidance for Superfund - Volume 1 - Human Health Evaluation Manual (Part A), U.S. EPA, December 1989.

- Region I, Supplemental Risk Assessment Guidance for the Superfund Program, Parts 1 and 2, U.S. EPA, June 1989.

- Risk Assessment Guidance for Superfund - Volume 1 - Human Health Evaluation Manual (Part A) "Supplemental Guidance" - Standard Default Exposure Factors, U.S. EPA, March 25, 1991.

- Guidance for Data Useability in Risk Assessment, U.S. EPA, October 1990.

- Dermal Exposure Assessment: Principles and Applications, U.S. EPA, January 1992.

Other references, from both EPA and non-EPA sources, will be utilized on an as-needed basis.

7.2 DATA EVALUATION/HAZARD IDENTIFICATION

Analytical and physical data collected during site investigations are evaluated during the first step of the risk assessment process.

7.2.1 Background Samples

The establishment of background chemical levels permits the risk assessor to both identify and differentiate between risks which are attributable to site-related contaminants and those risks which are attributable to naturally occurring chemicals. Background samples are usually identified as being off-site or outside of the investigation area (for soil) or onsite at upgradient (groundwater) or upstream (surface water and sediment) locations relative to the site being investigated.

Background data collected during the RI will be assembled separately from the environmental sample data and all statistical and numerical evaluations will be consistent with procedures outlined in guidance provided by the U.S. EPA.

7.2.2 Environmental Samples

Analytical data obtained from the analysis environmental samples provide the basis for the quantitative risk assessment. Sufficient numbers of samples are collected at locations within the investigated site to characterize the magnitude of chemical concentrations in all potentially affected media. Data will be grouped in such a manner that site- or area-wide risks can be characterized, however, care will be taken to avoid an underestimate of the relative presence of a particular chemical. For the investigation to be performed at the Melville North Landfill at Newport, Rhode Island, the scope of the investigation has been delineated and the sample collection requirements have been outlined in the Field Sampling Plan (Section 4.0) and the Quality Assurance Project Plan (Section 5.0).

For soils data, surficial and subsurficial data will be examined separately and together, resulting in the compilation of three soil data sets. All other data sets will be examined individually.

7.2.3 Representative Concentrations and Upper Confidence Limit Values

The Melville North Landfill analytical data will be statistically evaluated to quantify chemical exposures and to develop exposure concentrations. For all media the 95% Upper Confidence Limit (UCL) on the arithmetic mean will be used as the contact (representative) concentration. The 95% UCL value represents the upper bound average of a data set with a 95% statistical confidence level.

The calculation of the representative concentration is a two-step process. First, the standard deviation of the sample set will be determined, as follows:

$$S = \sqrt{\frac{(\sum X_i)^2 - \frac{1}{n} \sum X_i^2}{n - 1}}$$

where:

S	=	*Standard deviation*
X_i	=	*Individual sample value*
n	=	*Number of samples*
X	=	*Mean sample value*

The one-sided upper 95 percent confidence limit (UCL) on the arithmetic mean will then be calculated as follows:

$$UCL = X + t\,[S/n^{1/2}]$$

where:

X	=	*Arithmetic average value*
t	=	*One-sided t distribution factor* ($t_{0.95}$)
S	=	*Standard deviation*
n	=	*Number of samples*
UCL	=	*Representative concentration*

For nondetected results, one-half of the reported quantitation limit will be used as the sample result. For small sample sets or sample sets with all positive results less than one-half the detection limit, the UCL can exceed the maximum detected concentration. In these cases, the maximum concentration will be selected as the representative concentration.

When duplicate samples are evaluated, the results are averaged and counted as one sample. One-half the detection limit is substituted for nondetects when calculating the UCL. However, there are instances where one-half the detection limit exceeds the other sample's positive detection (e.g., with base/neutral or acid extractable compounds), in which case the positive detection will be considered as the sample result. Chemical results qualified as nondetected because of the presence of blank contaminants during data validation will be included in the data evaluation. However, revised quantitation/detection limits which are lower or significantly higher (greater than twice) than unqualified respective quantitation/detection limits will be to be disregarded to avoid skewing the interpretation of the data.

7.2.4 Toxicologically Based Screening Values

Although not developed by U.S. EPA Region I, a collection of toxicologically-based screening values has been developed by risk assessors at U.S. EPA Region III. The tables are presented in the document entitled "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (EPA/903/R-93-001, January 1993). The table summarizes medium-specific concentrations for potential contaminants which correspond to targeted noncancer risk levels (hazard quotient equal to 0.1) and carcinogenic risk levels (10^{-6} individual excess cancer risk).

Although the tables are not intended to be a complete and comprehensive risk assessment tool, they are useful in identifying exposure routes and chemicals which may pose unacceptable risk levels to receptors. The chemical-specific values will be compared to chemical-specific representative concentrations for the appropriate receptor-exposure routes to assist in identification of potential chemicals of concern.

7.2.5 Chemical of Potential Concern Selection

Positively detected chemicals in site media will be tabulated for selection of potential chemicals of concern. For each chemical, the data distribution, representative concentration, background concentration, and toxicologically-based screening value will be presented. Also, the last column of the table will be used to identify (using either yes or no designations) if the chemical will be retained as a potential chemical of concern for that medium. Chemicals for which no toxicological data are available (such as aluminum) or which are considered to be essential nutrients (calcium, iron, magnesium, potassium, and sodium) may be omitted from the table, however, a discussion supporting

exclusion from the table will be provided. All chemicals which are retained as potential chemicals of concern will be carried throughout the entire risk assessment process.

7.3 EXPOSURE ASSESSMENT

The exposure assessment will be conducted to provide a quantitative measure of chemical exposure for human receptors whom are exposed under specified exposure scenarios. The assessment process will identify receptors, applicable modes of exposure, and numerical estimation techniques which are consistent with a conceptual site model. The model will be used to identify reasonable current and future exposures.

In order to quantitatively evaluate chemical exposures, several requirements must be satisfied. First, a chemical must be present in an environmental medium (soil, water, air, etc.). Secondly, a release and transport mechanism is required to facilitate physical contact with the contaminated medium. Finally, a receptor is required to actually absorb the chemical. If any of the prescribed conditions are not met by a potential exposure route from the Melville North Landfill site, that exposure route will be considered to be incomplete and that no quantifiable exposure is present. For the exposure assessment, a conceptual site model will identify receptors and activity patterns that permit quantitation of chemicals which can be absorbed under reasonable exposure.

Two exposures are quantified for each scenario, namely central tendency (CT) and reasonable maximum exposures (RME). Central tendency exposures are intended to evaluate the "typical" receptor's exposure to contaminated site media, whereas the RME is considered to evaluate maximum exposure behavior or activities which may result in higher than usual exposure, such as gardening or strenuous physical training.

7.3.1 Conceptual Site Model

The conceptual site model is the basis upon which the risk assessment stands and will be used to identify relevant receptors and exposure pathways. The model considers current and future land use to present reasonable exposure scenarios for select receptors.

Current land use at NETC Newport, RI could result in exposure by individuals engaged in periodic maintenance activities and daily activities at the center. No exceptional or unexpected activities are assumed under this current land use site model.

A future land use scenario considers development of the center into a residential or commercial/industrial area. In either case, the development requires short term periods of construction followed by long term, low impact occupation of the sites.

7.3.2 Receptors

Individuals which may come into contact with contaminated site media will be identified as receptors. The term receptor is generically used in human health and ecological risk assessments to identify the biological organism which may be exposed to chemical contamination as a result of routine activity.

Consistent with the conceptual site model, current receptors include only adolescents who may trespass onto the site. For this receptors, the exposure time and frequency at any site is short, as the behavior patterns are typified by transience. Other nearby residents and employees are not likely to come into contact with the sites on a regular and quantifiable basis; such exposure is considered incomplete and will not be addressed.

Future land use may be assumed to include development for residential or commercial/industrial land use. As a requirement, receptors involved in any construction at the sites would certainly contact potentially contaminated media. Also, long-term occupants at the developed sites, residents, may also be exposed to contaminated site media. Employees under a commercial/industrial development scenario are presumed to be exposed at too small of a contact rate to be accurately quantified, and will not be considered.

7.3.3 Exposure Routes

Ingestion, dermal contact, and inhalation are the primary absorption routes for chemicals in environmental media. Standard routes of exposure are consistent with the media to which receptors are exposed. For example, soil chemicals may be absorbed via incidental ingestion, dermal contact, and/or inhalation of fugitive dust. Groundwater chemicals may be absorbed through ingestion of or dermal contact with groundwater, or via inhalation of volatiles generated in the shower. Exposure to surface water and sediments are assumed to happen concurrently via ingestion and dermal contact exposure routes.

The exposure routes that are determined to be consistent with the conceptual site model and with inferred behavior patterns of the receptors will be evaluated during the risk assessment. The applicable exposure routes will be identified on a receptor-specific basis.

7.3.3.1 Current Land Use

Under the current land use scenario, only adolescent trespassers may be exposed to contaminated site media. These incidental trespassers are subjected to exposure to soil via incidental ingestion and dermal contact. The inhalation exposure route is not considered for dust as the site is presumed to be well vegetated. Although subsurface soil contamination is noted to be present, it is unreasonable to assume that the trespasser will be involved in intrusive activities, consequently, only surficial soil data will be used in the exposure assessment for this receptor. Ingestion and dermal contact exposures for surface water and sediment are also considered to be complete exposure pathways.

7.3.3.2 Future Land Use

Future land use exposure scenarios include: construction workers who contact soil; industrial/commercial receptor contact with groundwater; recreational contact with soil, groundwater, surface water, and sediment; and recreational consumption of clams.

7.3.4 Exposure Estimates

Exposure estimates will be performed for each potential chemical of concern using current estimation techniques for each appropriate receptor-exposure route combination. The dose estimates will be presented in tabular format and include carcinogenic and noncarcinogenic exposure.

7.3.4.1 Ingestion Exposure

Ingestional exposures will be characterized using the following expression (U.S. EPA, December 1989):

$$Dose = \frac{C \times IngR \times EF \times ED}{BW \times AT}$$

Where:	Dose	=	Dose estimate (mg/Kg-day)
	C	=	Chemical contact concentration (ppm)
	IngR	=	Ingestion rate (Kg/day or L/day)
	EF	=	Exposure frequency (days/year)
	ED	=	Exposure duration (years)
	BW	=	Body weight (kg)
	AT	=	Averaging time (period of time over which exposure is averaged - days)

Input parameters for the ingestion exposure route are to be obtained from Region I guidance documents (for CT and RME exposures) and Agency-wide sources (for all other input parameters).

7.3.4.2 Dermal Exposure

Dermal exposures for receptors exposed to soil or sediment will be estimated as follows (EPA, January 1992):

$$Dose = \frac{C_{soil} \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:	Dose	=	Absorbed chemical dose (mg/Kg-day)
	C_{soil}	=	Contact concentration (mg/Kg)
	SA	=	Skin surface area available for contact (cm^2/event)
	AF	=	Soil-to-skin adherence factor (mg/cm^2)
	ABS	=	Transdermal absorption factor (fraction)
	EF	=	Exposure frequency (events/year)
	ED	=	Exposure duration (years)
	BW	=	Body weight (kg)
	AT	=	Averaging time (period of time over which exposure is averaged - days)
	CF	=	Conversion Factor ($Kg/10^6$ mg)

For exposure to dissolved phase chemicals in aqueous media (groundwater and surface water), the following equation will be used (EPA, January 1992):

$$Dose = \frac{C \times PC \times SA \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where: Dose = Absorbed chemical dose (mg/Kg-day)

C = Contact concentration (ppm)

PC = Dermal permeability constant of chemical (cm/hour) - aqueous

SA = Skin surface area available for contact (cm^2)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period of time over which exposure is averaged - days)

CF = Conversion Factor ($L/10^3$ cm^3)

Input parameters for the dermal exposure route are specified in Regional- and Agency-wide guidance documents.

7.3.4.3 Inhalation Exposure

Inhalational exposures during showering were estimated using a mass transfer model developed for this exposure route, in combination with an intake estimation model. The mass transfer model accounts for inhalation that occurs during a shower, as well as after the shower while the receptor remains in the bathroom. The method employed to determine inhalation exposure will be as follows (U.S. EPA, December 1989; Foster and Chrostowski, 1987):

$$Dose = \frac{S \times K \times InhR \times EF \times ED \times CF}{BW \times AT \times R_a}$$

and

$$K = D_s + \frac{\exp^{-R_a \times D_t}}{R_a} - \frac{\exp^{R_a (D_s - D_t)}}{R_a}$$

Where: Dose = Inhalation exposure dose (mg/Kg-day)

S = Volatile Chemical Generation Rate ($\mu g/m^3$-min)

InhR = Inhalation Rate (L/min)

EF	=	Exposure Frequency ($year^{-1}$)
ED	=	Exposure Duration (years)
BW	=	Body Weight (Kg)
AT	=	Averaging Time (period of time over which exposure is averaged - days)
R_a	=	Air exchange Rate (min^{-1})
K	=	Constant (min)
D_s	=	Shower Duration (min)
D_t	=	Total Time in Bathroom (min)
CF	=	Conversion Factor (10^{-6} mg-m^3/μg-L)

The volatile chemical generation rate will be estimated using the Foster and Chrostowski mass transfer model, which is based on a two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's Law constants, droplet drop time, viscosity, temperature, etc.

It is assumed that small children do not take showers, and are therefore not exposed in this manner.

Regional and Agency-wide exposure input parameters for CT and RME exposures will be utilized as appropriate for the inhalation exposure route.

7.4 TOXICITY ASSESSMENT

The purpose of this section is to identify the potential health hazards associated with exposure to each of the chemicals of concern. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that the chemicals of concern cause carcinogenic and/or noncarcinogenic health effects in humans. In addition, many of the chemicals have adverse effects on environmental receptors. Although the chemicals of concern may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the intake with the probability of toxic effects, as discussed below.

A summary table will be generated which presents dose-response information and any ARARs for the potential chemicals of concern. The text of the toxicity assessment will focus on the basis for the criteria, and summarize the regulatory standards as enforceable or nonenforceable.

7.4.1 Human Health Effects

An important component of the risk assessment process is the relationship between the intake of a chemical (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from that intake. Dose-response relationships provide a means by which potential public health impacts may be quantified. The published information of doses and responses will be used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

Standard Reference Doses (RfDs) and/or Cancer Slope Factors (CSFs) have been developed by the EPA for many organics and inorganics.

Dose-response data will be obtained from approved EPA and non-EPA sources in a hierarchial fashion. The sources to be utilized, in order of preference, include:

- Integrated Risk Information System (IRIS),
- Health Effects Assessment Summary Tables (HEAST),
- U.S. EPA Criteria Documents,
- Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, and
- Communications with EPA's Environmental Criteria and Assessment Office via EPA Region I RPM and/or Risk Assessment contacts.

The following subsections detail the toxicological information that will be acquired.

7.4.1.1 Reference Doses (RfDs)

The RfD is developed by the EPA for chronic and/or subchronic human exposure to hazardous chemicals and is solely based on the noncarcinogenic health effects imparted by a chemical. The RfD is usually expressed as a dose (mg) per unit body weight (Kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOEL or NOAEL) or a lowest-observed-adverse-effect-level (LOAEL) by an appropriate uncertainty factor. NOAELs, etc., are determined from laboratory or epidemiological toxicity studies. The uncertainty factor is based on the availability of toxicity data.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the toxicity data. A factor of 10 is used to account for variations in population sensitivity, when extrapolating test results from animals to humans (interspecies variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop the RfD, and when a LOAEL is used instead of a NOAEL. In addition, the EPA reserves the use of a modifying factor of up to 10 for professional judgment of additional uncertainties. The default value of the modifying factor is 1.

The RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus the RfD is an acceptable guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation.

All available reference doses will be presented for the potential chemicals of concern along with the target organ(s) which are affected by exposure. The information will be used to identify the potential for adverse health effects to the reference tissue.

7.4.1.2 Cancer Slope Factors (CSFs)

CSFs are applicable for estimating the lifetime probability (assuming a 70-year lifetime) of human receptors developing cancer as a result of exposure to known or potential carcinogens. This factor is generally reported by the EPA in units of $(mg/Kg/day)^{-1}$ and is derived through an assumed low-dosage linear relationship and an extrapolation from high to low dose responses determined from animal studies. The value used in reporting the CSF is the upper 95 percent confidence limit.

Several polynuclear aromatic hydrocarbons (PAHs) have published toxicity equivalence factors (TEFs) which allow determination of carcinogenicity based on the cancer slope factor of benzo(a)pyrene, a commonly detected PAH compound. The TEF approach will be used for assessment of PAH risks.

7.4.1.3 Weight of Evidence Classification

The weight of evidence designations indicate the likelihood that a chemical is a human carcinogen, based on both animal and human studies. The classification is as follows:

- A Known human carcinogen
- B Potential human carcinogen. B1 indicates that limited human data are available. B2 indicates that there is sufficient evidence of carcinogenicity in animals, but inadequate or no evidence in humans.
- C Possible human carcinogen
- D Not classifiable as to human carcinogenicity
- E Evidence of noncarcinogenicity in humans

7.4.1.4 Dermal Absorption Adjustment

Although exposure route-specific reference doses and cancer slope factors are available for oral and inhalation exposure routes, the difficulty associated with performing an epidemiological study for dermal exposures prohibits accurate assessment of toxicity via dermal absorption. As a default measure, U.S. EPA guidance suggests using oral reference doses and cancer slope factors which have been modified to account for the gastrointestinal absorption.

Readily absorbed chemicals (i.e., volatile organics, etc.) can be assumed to be absorbed 100% through the GI tract, whereas most metals are absorbed poorly in the digestive tract. Therefore, for animal studies performed by gavage, volatile chemicals are almost entirely absorbed, while metals are only minimally retained. The administered dosage is approximate equal to the absorbed dose for the volatile chemical, but the absorbed dose is vastly different from the administered dosage in the case of the metal. Since dermal risk assessment methodology accounts for the transdermal transport of chemicals into the bloodstream, absorbed dose values must be used.

The use of adjusted oral data permits assessment of the effects associated with the absorbed amount of chemical which has actually entered the bloodstream. The chemical-specific modification for reference doses and cancer slope factors will be performed as follows:

$$RfD_{Dermal} = \frac{RfD_{oral}}{ABS_{GI}}$$

$$CSF_{dermal} = CSF_{oral} \times ABS_{GI}$$

7.4.1.5 Integrated Uptake/Biokinetic (IUBK) Model for Lead

Currently, there is no reference dose or cancer slope factor available for evaluating risks posed by exposure to lead. Consequently, the U.S. EPA has developed the IUBK model which assesses lead uptake for child receptors and provides a predicted blood lead level for the receptor. These blood lead levels are compared to a reference concentration of 10 μg/dL to qualitatively assess risk potential. Although no threshold effects level has been documented for lead exposure, the use of this model does provide an assessment of lead exposures. The model will be used for risk evaluation due to lead exposures.

7.4.2 Applicable or Relevant and Appropriate Requirements (ARARs)

This section presents the available regulatory standards or guidelines for all of the groundwater chemicals of concern at NETC Newport, RI. Currently, the enforceable regulatory standards for exposures to site groundwater include Federal Maximum Contaminant Levels (MCLs) and state groundwater quality standards. Some chemicals do not have regulatory limits promulgated, so other numerical comparison must be made. These to be considered (TBC) values are nonenforceable criteria and may be used for comparative purposes to infer health risks and environmental impacts. Relevant TBC guidelines include Maximum Contaminant Level Goals (MCLGs) and Health Advisories. All ARARs and TBCs presented in the following summary will be presented in tabular format for each medium-specific potential chemical of concern identified as being present at the site.

As part of the ARARs presentation, all applicable state standards will be presented for comparison to groundwater data. Exceedences of applicable standards will be identified and discussed in the risk characterization section of the risk assessment.

7.4.2.1 Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiologic studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 Kg) who consumes 2 liters of water per day, but they also reflect the technical feasibility of removing the contaminant from the water. These enforceable standards also reflect the fraction of toxicant expected to be absorbed by the gastrointestinal tract.

7.4.2.2 Maximum Contaminant Level Goals (MCLGs)

MCLGs are generally specified as zero for carcinogenic chemicals, based on the assumption of nonthreshold toxicity, and do not consider either the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based entirely on health effects. The MCLs are set as close to the MCLGs as is considered technically and economically feasible.

7.4.2.3 Health Advisories

Health Advisories are guidelines developed by the EPA Office of Drinking Water for nonregulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (with an assumed body weight of 10 Kg) who consume 1 liter of water per day, or in adults (with an assumed body weight of 70 Kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (longer-term or lifetime) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of known or probable human carcinogens.

7.4.2.4 Federal Ambient Water Quality Criteria (AWQC)

Surface water data are comparable to Federal AWQC to provide a qualitative assessment of contamination in surface water. AWQCs are nonenforceable Federal guidelines and are of primary utility in assessing the potential for toxic effects in aquatic organisms. They may also be used to identify the potential for human health risks. AWQCs consider both the acute and toxic effects from ingestion of both water (2 L/day) and aquatic organisms (6.5 g/day), and from ingestion of aquatic organisms alone.

7.4.2.5 National Oceanic and Atmospheric Administration (NOAA) Effects Range Values for Sediment

The NOAA Effects Range values are used to determine the potential for adverse effects on benthic, invertebrate, and vertebrate aquatic lifeforms at low and median effects levels. The effects levels correspond to chemical-specific sediment concentrations which result adverse biological affects in the lower 10 percentile (Effects Range-Low or ER-L) and the median (Effects Range-Median or ER-M) of a surveyed population. The ER-L value will be used for evaluating sediment toxicity to aquatic organisms.

7.4.2.6 Rhode Island State Groundwater Quality Standards

Groundwater quality protection standards are presented in the Rhode Island Groundwater Protection Act (Rhode Island General Laws, Title 46, Chapter 13.1) and Drinking Water Laws (Chapter 13). The acts provide a classification system for groundwater based on potential use and mandates the Rhode Island environmental standards board to adopt maximum contaminant level criteria.

As part of the ARARs presentation, all applicable state standards will be presented for comparison to groundwater data. Exceedences of applicable standards will be identified and discussed in the risk characterization section of the risk assessment.

7.4.2.7 Rhode Island State Surface Water Quality Standards

Surface water quality standards for the State of Rhode Island are outlined in the Rhode Island Water Quality Standards (Rhode Island Department of Environmental Management, Regulations for Water Pollution Control, Section 6.0). The rule establishes a classification system for surface water consistent with the most sensitive use, and allows for protection to that designated use for the watershed. All surface water bodies within the state are identified in the ruling and quality criteria are presented which are protective of human health and the environment.

Surface water data will be discussed in the risk assessment and these relevant Rhode Island water quality standards will be presented for comparative purposes.

7.5 RISK CHARACTERIZATION

Potential human health risks resulting from the exposures outlined in the preceding section are characterized on a quantitative and qualitative bases in this section. Quantitative risk estimates are generated based on risk assessment methods outlined in current U.S. EPA guidance (U.S. EPA, December 1989), and the qualitative assessment consists of a comparison of measured concentrations to standards or guidelines.

Noncarcinogenic risk estimates are presented in the form of Hazard Quotients and Hazard Indices that are determined through comparison of estimated intakes with published Reference Doses. Incremental cancer risk estimates are provided in the form of dimensionless probabilities based on Cancer Slope Factors.

Estimated human intakes were developed for each of the specific exposure routes discussed in the preceding sections. Both carcinogenic and noncarcinogenic risks are summarized for each exposure route on a series of tables that will be presented in the risk assessment section of the RI report.

7.5.1 Hazard Quotients

Noncarcinogenic risk is assessed using the concept of Hazard Quotients and Hazard Indices. The Hazard Quotient for a selected chemical of concern is the ratio of the estimated intake and the Reference Dose (RfD) and will be calculated for site chemicals as follows:

$$\textit{Hazard Quotient (HQ)} = \frac{Dose}{RfD}$$

A Hazard Index is generated by summing the individual Hazard Quotients for the chemicals of concern. If the value of the Hazard Index exceeds unity (1.0), there is a potential noncarcinogenic health risk associated with exposure to that particular chemical mixture (U.S. EPA, September 24, 1986). Should this occur, particular attention will be paid to the target organs affected by each chemical. The Hazard Index is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects. If the ratio of the intake and the RfD for any individual chemical exceeds unity, toxic effects would also be expected.

7.5.2 Incremental Cancer Risk

Incremental cancer risk estimates will be generated for each of the exposure pathways using the estimated intakes and published Cancer Slope Factors (CSFs), as follows:

$$\textit{Incremental Cancer Risk (ICR)} = Dose \times CSF$$

If the above equation results in a risk greater than 0.01, the following equation will be used:

$$ICR = 1 - \exp^{(-Dose \times CSF)}$$

The risk determined using these equations is a unitless expression of an individual's likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An incremental cancer risk of 1×10^{-6} indicates that the exposed receptor has a one in one million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The calculated cancer risks should be recognized as upper-limit estimates. Cancer Slope Factors are the upper 95 percent confidence limit of a dose-response curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on the CSFs, and, in fact, may be lower.

The U.S. EPA has generally defined risks in the range of 10^{-4} to 10^{-6} as being acceptable for most hazardous waste facilities addressed under CERCLA. For CERCLA activities, residual risks on the order of 10^{-6} are the primary goal, but are often modified by such regulatory requirements as MCLs or chemical-specific cleanup goals. Cancer risks will not be calculated for small children because of the short (i.e., 6 years) exposure duration, unless no other receptors are to be considered for an exposure route.

7.5.3 Uncertainty Analysis

Carcinogenic and noncarcinogenic health risks are estimated using a number of different assumptions; therefore the values presented in this section contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent upon the accuracy with which the toxicity of a chemical can be estimated and the accuracy of the exposure scenario assumptions. The toxicologic data that form the basis for all risk assessments contain uncertainty in the following areas:

- The extrapolation of nonthreshold (carcinogenic) effects from the high doses administered to laboratory animals to the low doses received under more common human exposure scenarios.

- The extrapolation of the results of laboratory animal studies to human or environmental receptors.

- The interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical.

- The variations in sensitivity among individuals of any particular species.

In addition to these sources of uncertainty, the exposure estimates are also based on a number of simplifying assumptions. The assumptions made include the following:

- Receptor characteristics, such as age, body weight, and exposure duration, are based on published values, with some attempt at making them more site-specific.

- Land use and activity patterns in the area are limited to the observations made during the field investigation and known land uses in the surrounding area.

- There are no antagonistic or synergistic effects between the chemicals of concern.

The chemical analytical data base also has some limitations in such areas as sample number and location, and the representativeness of the laboratory results. The risk assessment will address these uncertainties and discuss the impact that may be incurred on the results and conclusions of the risk assessment.

8.0 RISK ASSESSMENT - ECOLOGICAL ASSESSMENT

This section presents the approach for performing an Ecological Assessment for the Melville North Landfill site. The Ecological Assessment will be conducted according to the EPA guidance document Risk Assessment Guidance for Superfund, Volume II Environmental Evaluation Manual (U.S. EPA, 1989), guidance developed by EPA Region I in their Supplemental Risk Assessment Guidance for the Superfund Program, and ECO Update - Ecological Assessment of Superfund Sites: An Overview (U.S. EPA, 1991).

The overall objective of the Ecological Assessment is to provide a qualitative and quantitative assessment of the on-shore environmental risks and/or impacts associated with conditions at the site. These conditions include the presence of chemical contaminants in soil and groundwater and the potential that some of these chemicals are reaching adjacent wetlands or marine environments (Narragansett Bay). Thus, the assessment will consider ecological components within on-site wetland and terrestrial environments. The work covered by this work plan will not be extended into the intertidal zone at the site, or into the marine ecosystem in order to avoid duplication of a University of Rhode Island (URI) study. (URI is currently engaged in a contract with the Navy to study the effects of NETC sites on the Marine Ecosystem. The URI study will eventually include the near-shore and off-shore areas at the Melville North Landfill, and provide an off shore risk analysis for this site.)

The specific objectives of the overall assessment will be to:

- Identify ecological components or species that may be exposed to chemicals associated with existing conditions at the site;
- Select endpoints of concern (e.g., reproduction, survival);
- Identify the pathways and routes by which ecological components may be exposed to site contaminants;
- Identify contaminant transfer mechanisms;
- Estimate exposure point concentrations;
- Provide published information on the known toxic effects of the site contaminants;

- Characterize the environmental risks associated with the exposure under current and future conditions;

- Assess the uncertainties associated with the estimates; and,

- Discuss the ecological significance of the findings.

The Ecological Assessment will use a "weight of evidence" approach that includes direct field observations, selected field and laboratory studies, and chemical analytical data evaluation relative to environmental benchmarks. When integrated into the overall assessment, these methods will provide a perspective on the nature of ecological risks at the site.

This plan for ecological assessment follows the organization suggested in the recent Eco Update (U.S. EPA, 1991) but also includes all elements of an assessment, as identified in the U.S. EPA Region I Supplemental Risk Assessment Guidance for the Superfund Program. The Region I guidance includes: objectives definition; site characterization; potential receptors identification; chemicals selection; species identification, and endpoints for risk assessment; exposure assessment, toxicity assessment, and risk characterization.

This plan for ecological assessment has six major sections.

- Background and Site Description - This section provides a brief overview of the site and describes what is known concerning the extent of contamination in relation to ecological components. The background and site description data serves as basis for identifying important aspects of the site and data needed to complete the assessment.

- Plan for Site Characterization - This section describes surveys that will be performed on the non-marine habitats at the site. It also describes how the investigation described in previous sections of the work plan will characterize the site relative to pertinent ecological components (receptors). Such information is important for all parts of the Ecological Assessment but specifically will be used in the Problem Formulation component.

- Plan for Problem Formulation - This part of the assessment plan describes the activities that will identify contaminants of ecological concern; ecological components (receptors) for evaluation; endpoints of concern; exposure pathways; and known

effects. The Problem Formulation will provide the basis for proceeding with the subsequent portions of the Ecological Assessment.

- Plan for Exposure Assessment - This section of the assessment plan describes how exposure point concentrations will be measured or estimated, and how those concentrations will interact with each receptor type.

- Plan for Ecological Effects Assessment - This section describes the sources of information to be used to identify toxicity of the site contaminants.

- Plan for Risk Characterization: This section describes the general methods that will be used to make qualitative and quantitative characterizations of risk. This section will also indicate how uncertainties will be characterized.

8.1 BACKGROUND AND SITE DESCRIPTION

This subsection provides a preliminary description of the habitat types represented at the site. For a complete history of the site, refer to Section 2.0 of this Work Plan.

The Melville North Landfill is located at the northern end of the NETC facility (see Figure 2-1) along the West shoreline of Acquidneck Island, which is located in Narragansett Bay. The Melville North Landfill is approximately 10 acres situated between Defense Highway and Narragansett Bay. The site is generally flat across its central to northern portions, with a ridge running along the eastern side of the southern portion of the site. The western boundary of the landfill extends to approximately 5 vertical feet above the mean high tide. The area is subject to periodic flooding and lies within the 100-year flood plain. Elevations increase in the easterly direction. Ground water flows east to west toward Narragansett Bay and is tidally influenced.

A review of site history indicates that no areas on the site exist that have not been disturbed by base operations. Upland vegetation in much of the site is restricted primarily to perennial weeds, grasses, shrubs, and small trees.

One wetland system is located near the site; a runoff area that bisects the site south to north, and feeds into a small saltmarsh located to the north of the site. Initial observations indicate that contributors to this wetland include groundwater outbreaks from the east side of Acquidneck Island and surface runoff from area roadways.

This site was operated as a landfill for approximately ten years. Wastes disposed of at the Melville North Landfill include spent acids, paints, oils, and possibly PCBs. Site investigations and aerial photographs indicated three primary areas of potential contamination: historic landfill areas, areas of surficial oily deposits, and previous lagoon sites.

Levels of metals in sediment and PCBs in mussel samples collected off shore of the Melville North Landfill during the 1993 Off-Shore Investigation (conducted by Bettelle Ocean Sciences) were determined to be consistent with background levels and not attributable to site-specific contamination.

This site was studied in the IAS and the CS. The RI investigations performed to date at this site include ambient air and radiological surveys, a geophysical survey, surface soil sampling, test pit excavations, test borings, ground water monitoring well installation and sampling, and sediment sampling in the marsh. Results from the RI indicated that the major areas of contamination on the site appear to be associated with the former lagoon locations in the central portion of the site and in the southern portion of the site, in the vicinity of well MW-4.

Elevated levels of VOCs (acetone, 2-butanone, chlorobenzene, 1,1,1-trichloroethane, and BETX), BNAs (PAHs and chlorinated compounds), PCBs, and inorganics were detected in soil samples collected in the central and southern portions of the site. PCBs were detected in soil samples collected from northwestern and northeastern portions of the site. Pesticides (4,4'-DDE and 4,4'-DDT) were detected at low levels in surface soils across the site; the highest pesticide levels were detected in the central portion of the site. Elevated inorganics were detected in soil samples collected from the northeastern portion of the site to just south of the access road. The highest levels were detected in subsurface soils at or below the water table in the north-central, central, and south-central portions of the site.

Petroleum-related VOCs (xylene, benzene) were detected in ground water samples from wells in the central and southern portions of the site. Oil was identified in well MW-3 in the central portion of the site. One pesticide (lindane) was also detected at this location. One BNA was detected at elevated levels in the southern portion of the site. PCBs were detected in wells in the central and southern portions of the site. Inorganics were elevated across the site, with the highest levels detected in the central and north-central portions of the site.

Analysis of the three sediment samples collected from the marshy area in the northern portion of the site indicated the presence of low levels of VOCs (toluene, carbon disulfide, 2-hexanone) and elevated BNAs (carcinogenic PAHs and phenols), pesticides (4,4'-DDE), and several inorganics. No PCBs were detected in sediment samples.

A pile of oil-soaked soil was apparently dumped in the northern portion of the site. A soil sample collected from the oily waste deposits contained over 3 percent petroleum hydrocarbons by weight, as well as an elevated level of lead. Test pit investigations did not show lateral or downward migration of oil from the waste deposits. This waste pile has been removed from the site under an interim remedial action performed by the Navy.

8.2 SITE CHARACTERIZATION

Site characterization will be performed using data generated in previous studies at the site, and during the performance of ecological field evaluations described in Section 4.2.4 of this Work Plan. The site characterization will:

- identify the types and spatial extent of habitats that are present on and around the site.
- identify the species and biological communities that may use these habitats and that may be potential receptors with regard to contaminants present in soils, sediments, and surface waters at the site.
- determine, through direct observation, the general functional condition of wetlands on the site.
- determine the extent and nature of contamination of environmental media with regard to potential exposure of receptor species.
- identify on-site and adjacent wetlands and their boundaries; provide maps of the wetland boundaries relative to the site; assess the functional value of the identified wetlands based on standard method; and contribute to the habitat descriptions of the site and nearby areas.

The Ecological Assessment will integrate this information with its goals. Data products generated, as described in Section 4.2.4, will be used in the exposure assessment and characterization of risk to help select appropriate receptors and describe the existing environment.

8.3 PLAN FOR PROBLEM FORMULATION

During the Problem Formulation stage of the Ecological Assessment, the overall objectives and scope will be established. To a large extent, the identification of the objectives and scope has already been

accomplished. In fact, work that has gone into preparation of this work plan is part of Problem Formulation. The following is a description of the components of the Problem Formulation to be developed further and finalized during execution of the work plan.

8.3.1 Identification of Contaminants of Concern

This task will identify ecological contaminants of concern relative for the Ecological Assessment. Factors that will be considered in identifying these contaminants include:

- Environmental concentrations in surface soils, sediments, surface waters, and groundwater that may discharge to marine or aquatic habitats;
- Frequency of occurrence of concentrations in these various media;
- Background levels and the extent to which contaminants exceed these levels;
- Bioavailability of the contaminants in soils and sediments, considering the site-specific factors (e.g., total organic carbon) that may affect bioavailability;
- Physical-chemical properties such as solubility, partitioning to lipids, and volatility that may affect the behavior, transport, and accumulation of the contaminant;
- Potential for bioaccumulation or bioconcentration;
- Potency of the chemical with regard to identified toxicological endpoints; and
- The kinds of effects that the contaminant may have and the potential that these effects may be additive or synergistic with those associated with other contaminants.

Based on a review of existing information, a number of candidate contaminants of concern exist at the base. These include selected volatile organic compounds (chlorinated and aromatic), semivolatile organic compounds (in particular polycyclic aromatic hydrocarbons), pesticides (in particular DDT and its residues), PCBs (in the landfill), and metals.

8.3.2 Identification of Exposure Pathways

An exposure pathway describes the links between the sources of contaminants and the ecological components (receptors) that may be exposed. Potential exposure pathways will be identified by considering the source locations, the media through which the contaminants may be transported; the potential for bioaccumulation, and the characteristics of the receptors. Animals and plants can come into contact with contaminants in different ways. Exposure routes can include direct contact and uptake with soils, sediment, or water, ingestion of food, incidental ingestion of soil, and inhalation.

8.3.3 Identification of Ecological Components (Receptors)

Ecological components including species, faunal types, and communities will be selected for evaluation. The identification of potential receptors (species) will be based on literature review and field observations conducted during the site characterization.

A list of ecological components to be assessed will be developed. This list will include species of animals and plants associated with aquatic, wetland, and terrestrial environments as well as functional groups and communities. The list will include those species, groups, and communities that are likely to occur at the site or (in the absence of toxicological data on such species) are phylogenetically or tropically similar to species likely to occur. The candidate species, groups, and communities will represent a reasonable cross-section of the major functional and structural components of the ecosystem under study. Consideration will be given to the inclusion of species or groups that represent different trophic levels (e.g. producers, saprophytes, herbivores, primary and secondary carnivores), a variety of feeding types (detritivores, scavengers, filter feeders, active predators), and several habitats (aquatic, wetland, and upland).

The assessment will focus on selected ecological components appropriate to each habitat type. Selection will be based on relative abundance and ecological importance within the wetland, terrestrial, and aquatic habitats, availability and quality of applicable toxicological literature, relative sensitivity to the contaminants of concern, trophic status, relative mobility, and local feeding ranges, ability to bioaccumulate contaminants of concern, economic importance or federal/state endangerment status, and any observed visible evidence of stress.

8.4 PLAN FOR EXPOSURE ASSESSMENT

The purpose of this section is to describe the steps in the development of an exposure assessment. According to recent EPA Guidance (ECO Update, December, 1991), an Exposure Assessment should

quantify "the magnitude and type of actual and/or potential exposures of ecological receptors to site contaminants". The key elements include quantification of contaminant release, characterization of receptors, and measurement or estimation of exposure point concentrations.

8.4.1 Quantification Of Release, Migration, And Fate

The purpose of this task will be to estimate current and future contaminant levels of all affected media. These estimates will be used to develop exposure point concentrations. In addition, contaminant loading into the marine ecosystem will be estimated, although exposure point concentrations will not be determined for the marine organisms since this will be dealt with as part of an upcoming off-shore ecological risk assessment.

To accomplish the first part of this task, the ecological assessment will rely upon direct measurements from sampling and predicted groundwater flow direction. The assessment will include summaries of these data in all relevant media. These summaries will reference maps of contaminant distribution and/or tabulated summaries, and reference or present statistical summaries, as appropriate, to clearly present the current distribution of contaminants by medium.

To accomplish the second part of this task, the information developed as described above will be supplemented with available data for precipitation, tidal flushing, and bathymetry. These data sets will be used to formulate an estimate of contaminant transfer to the marine environment. (A mathematical model quantifying contaminant loading into the marine ecosystem which accounts for all variables specific to the site has not yet been developed.)

8.4.2 Estimating Exposure In Soils From Organic Contaminants - Equilibrium Partitioning

The "available fraction" of the site contaminants in saturated soils will be evaluated by a two different methods. In the case of non-polar organic compounds (e.g. PAHs, PCBs) the Equilibrium Partitioning (EP) method will be used for estimating concentrations of compounds that may exist in soil moisture or pore water and to which invertebrates and plants will be exposed. The method takes into account the organic fraction of the soil, sediment, or wetland environment.

The EP method establishes relationships between non-ionic organic compounds present in the saturated soils and interstitial water. The predicted concentrations in the interstitial waters can then be compared with Ambient Water Quality Criteria (AWQC). The relationships are then used to develop sediment levels that would provide an adequate level of safety for aquatic communities.

The EP method assumes an organic compound in sediment and interstitial pore water achieves equilibrium over a short period of time. This equilibrium is governed by the extent of sediment adsorption. Numerous studies have established that for non-ionic organic compounds, adsorption occurs mainly via organic carbon. This sorption process can be quantified for a particular compound based upon its individual water/organic carbon partition coefficient. This organic carbon-based sorption model has been found to be valid for sediments containing at least 0.1 percent organic carbon.

This approach is valid only for non-ionic compounds. For ionic compounds or for inorganic elements, the EP approach is not valid. However, the approach may be valid for ionic compounds in their associated form (e.g., phenol below a Ph of 9). This method is valid for any type of sediment that contains more than approximately 0.1 to 0.5 percent organic carbon. The method assumes that ingestion of sediment is not a significant pathway of exposure.

The EP method allows for the establishment of a Sediment Quality Criteria (SQC) based upon organic carbon normalized values. Organic carbon and the sediment concentration(s) must be measured to compare the SQC to site-specific values and thereby determine possible risk.

8.4.3 Estimating Exposure In Sediments From Inorganic Contaminants - Acid Volatile Sulfides

The Acid Volatile Sulfide (AVS) approach addresses sediment criteria for metals. The method is similar to the EP method; both model the interstitial water concentration as a function of a limiting component of the sediment. The AVS approach was developed relatively recently, and is currently under review by EPA.

DiToro et al. (1990) have shown that insoluble metal sulfides (typically iron and manganese sulfide) are the controlling parameter in anoxic sediments reacting with available divalent metals such as cadmium and copper.

Since toxicity tests for metals have shown that toxicity correlates with divalent metal activity in interstitial water, it is assumed under the AVS method that if all of the divalent metal is bound to AVS, no toxicity to aquatic biota will result. By measuring both the amount of sulfide available in the sediment, as well as the amount of divalent metal (otherwise referred to as Simultaneously Extracted Metal, or SEM), one can determine stoichiometrically if all of the SEM is bound to AVS. If results indicate that SEM is less than AVS, then no metal is available to cause toxicity in organisms. However, if SEM exceeds AVS, then toxicity may or may not occur. Other adsorption processes may bind otherwise free metal to prevent bioavailability.

The AVS method can predict only at what concentrations toxicity will not occur in anaerobic sediments, but provides no information on the toxicity of sediments whose levels of SEM exceed AVS. Such sediments may or may not present a risk to biota, depending on other contemporaneous adsorption processes.

Since AVS is present only under anaerobic conditions, AVS concentrations have been observed to decrease dramatically near the upper few centimeters of sediment where bioturbation and scour are present. AVS has also been shown to vary seasonally, with the lowest concentrations in the winter, and the highest in the summer. DiToro (personal communication, 1991) has suggested that a winter minimum AVS concentration may be used as a conservative value.

Currently, AVS has been shown to be valid only for acute exposures, although initial indications suggest that a protection against chronic exposures may be valid as well. Cadmium, copper, mercury, nickel, lead, silver, and zinc are the inorganic elements that are considered valid using the AVS methodology.

8.4.4 Characterization Of Receptors

The Ecological Assessment will focus upon a limited number of selected receptors. The selection of receptors is part of the problem formulation (Section 8.3).

The characterization of receptors will include information on the species' feeding habits, life histories, habitat preferences, and other attributes that could affect their exposure or sensitivity to contaminants. The characterization of receptors (species) for this site will derive from: the reviews of literature (Section 8.5.1); reviews of existing studies; results of surveys described in Section 8.2; and field observations made during site characterization (Section 8.2).

Categories of receptors are expected to include the following:

- terrestrial and wetland vegetation,
- soil biota,
- mammals and birds,
- benthic invertebrates within the on-site wetland system

For each receptor, the assessment will include a characterization in the form of a species profile. These profiles will be text descriptions of the relevant ecological and physiological characteristics and taxonomic relationships of the receptors. The profiles will include but not be limited to descriptions

of: trophic status, feeding type, food preferences, ingestion rates, range, prey, predators, migratory habits, breeding habits, likely habitats, population estimates, reproductive strategies, substrate and habitat preferences. The profiles will also include any particular vulnerabilities or status of the species as rare or endangered.

8.4.5 Estimation of Exposure Point Concentrations

According to EPA guidance, exposure point concentration is an estimate of the concentration of contaminants in the media to which the receptors are exposed. This is either measured in the environmental medium or estimated using assumptions and/or fate and transport modeling. The estimates of exposure point concentrations in each medium will generally follow EPA Guidance (Section 6.5, "Risk Assessment Guidance For Superfund Volume I, Human Health Evaluation Manual (part A)", EPA/540/1-89/002). This guidance indicates that direct use of monitoring data is normally applicable where exposure involves direct contact with the monitored medium as in the case of soils; modeling is appropriate when exposure points are spatially separate from monitoring points, where spatial distribution of data is lacking, or where monitoring data are restricted by the limit of quantitation; and that the objective of determining exposure point concentrations is to provide a conservative estimate of the average concentration contacted at the exposure point over a the period of exposure.

Exposure point concentrations will be estimated based on field data and modeled concentrations. The on-site and off-site data base will be sufficient for this purpose.

Exposure point concentrations will be presented in tables that include the pathway, receptor, estimate of exposure point concentrations, and comments summarizing the source or derivation of the estimate.

8.5 PLAN FOR ECOLOGICAL EFFECTS ASSESSMENT

Ultimately, the ecological risk characterization will be used to identify, compile, and evaluate the data necessary to relate exposure point concentrations to the effects on the receptors. The characterization requires developing toxicological information related to the selected receptors. Such information will be obtained from the literature on the effects of site-related contaminants. Additional information on ecological effects will be drawn from site-specific field observations and toxicity testing.

This effects assessment will identify the range of toxic endpoints and discuss potential biological effects of site-related contaminants within various concentration ranges. The endpoints may include: lethality, reproductive impairment, behavioral modifications, or various sublethal toxic effects.

Endpoints may also include secondary effects such as loss of habitat. This analysis is used to select toxic endpoints for eventual risk characterization.

8.5.1 Literature Review

Much of the information for this part of the analysis will be drawn from the scientific literature. Computerized literature searches and reviews of the recent primary literature will be used to supplement information that is readily available for the contaminants of concern. A search will be made for recent data in EPA's AQUIRE data base for data on effects on aquatic organisms. Recent publications in the Society of Environmental Toxicology and Chemistry (SETAC) journal and at recent SETAC symposia are helpful in identifying the most recent research.

The review of data sources will include the RIDEM and the USFWS. In addition, an on-line literature search will be performed to develop background information concerning any recent publications regarding wildlife habitats in the general geographic area.

The following data bases are used to obtain information on wildlife, fish and benthic invertebrates: Bios Previews; Life Sciences Collection; Zoological Record Online; Enviroline; Pollution Abstracts; Oceanic Abstracts; and CAB Abstracts. These data bases are available through the DIALOG Information Services. The TOXNET (TOXicological NETwork), AQUIRE, and IRIS (Integrated Risk Information System) databases are accessed via the National Library of Medicine's MEDLARS system.

8.5.2 Use of Terrestrial, Aquatic, and Wetland Field Studies

Field observations and the wetlands functional analyses will be used to help characterize conditions at the site. Direct observations may reveal ecological effects such as stressed vegetation, reduced species diversity, presence of opportunistic species, or pathologies. This information will be evaluated with regard to the potential effects of contaminants of concern.

8.6 PLAN FOR RISK CHARACTERIZATION

8.6.1 Potential Habitat Modification

Potential risks associated with habitat modification will be evaluated. These may be related to physical alterations of soil, sediment, or freshwater flow environments as well as to other alterations that would impact the quality of the habitat.

8.6.2 Risks Due to Toxic Effects of Contaminants

A qualitative and quantitative assessment of risks to ecological receptors will be performed with regard to toxic effects. This analysis will use information generated from the Exposure and Ecological Effects Assessments and will rely upon the Toxicity Quotient approach, as well as on direct observations of conditions in the field, to provide an overall weight of evidence concerning the nature of risks.

The quotient approach involves calculating the ratio of each measured or estimated exposure concentration to benchmark toxicity values identified in the ecological effects assessment. Values that exceed "1" are considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded.

Average and maximum exposure concentrations will be compared using this method. If both exceed the benchmark, then effects are probable of a more widespread occurrence at the site. If only the maximum concentration exceeds the benchmark, then effects are possible, and a more localized occurrence may be present at the site.

This risk characterization method provides some insight into general effects upon animals in the local population. However, the method does not indicate if population-level effects will occur. Such an assessment requires careful consideration of the local factors affecting populations. If effects are judged to be insignificant at the average individual level, they are probably insignificant at the population level. However, if risks are present at the individual level they may or may not be important at the population level.

8.6.3 Presentation Of Risk

Toxicity quotients will be presented in a table describing each receptor and exposure concentration for each contaminant of concern. Separate quotients will be presented for average and maximum exposure concentrations derived in the exposure assessment. A discussion will be presented that will provide a qualitative description of the other factors influencing the toxic effects on individuals and populations.

Additional discussion will be presented to summarize the uncertainties that are inherent in the methods and the data that are used in the risk assessment. This discussion will support or qualify the conclusions of the ecological assessment.

9.0 ARARs AND PRELIMINARY REMEDIAL ACTION ALTERNATIVES

A preliminary identification of potential Applicable or Relevant and Appropriate Requirements (ARARs) in the scoping phase can assist in the initial identification of general response actions, technology types, preliminary remedial alternatives, and in the identification of additional data needs. This document provides a preliminary assessment of ARARs as they apply to the Melville North Landfill-NETC-Newport site and provides a preliminary identification of potential remedial action alternatives. The Feasibility Study process, which will build upon this information, is discussed in detail in Section 10.0.

9.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA, 1986), and the National Oil and Hazardous Substances Contingency Plan (NCP, 1990) require that all remedial response actions attain or exceed applicable or relevant and appropriate requirements (ARARs) of Federal and, if they exist, the more stringent promulgated requirements of State environmental statute(s). The NCP defines applicable requirements as: "... those cleanup standards, standards of control, other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." Relevant and appropriate requirements are defined in the NCP as: "... those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at the CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

The current Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA/540/G-89/004, OSWER Directive 9355.3-01) calls for a preliminary identification of potential ARARs during the RI scoping phase to assist in initial identification of remedial technologies and alternatives. Early identification also facilitates communications with support agencies to evaluate ARARs, and may help planning of field activities. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as better understanding is gained of the site

conditions, site contaminants, and as remedial action alternatives are developed. Findings of the Phase I RI have aided in the selection of ARARs identified within this document.

ARARs may be categorized as: 1) chemical-specific requirements, which may define acceptable exposure levels and, therefore, be used in establishing preliminary remediation goals; 2) location-specific, which may set restrictions on activities within specific locations such as floodplains or wetlands; and 3) action-specific requirements, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes. The documents, CERCLA Compliance With Other Laws Manual (U.S. EPA, 1988), and CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements (U.S. EPA, 1989), contain detailed information on identifying and complying with ARARs.

Preliminary lists of Federal and State of Rhode Island ARARs have been compiled for Melville North Landfill Site and are presented in Tables 9-1 through 9-6. Refinement of ARARs will continue throughout the RI/FS.

Non-promulgated advisories or guidance issued by Federal or State government that are not legally binding and do not have the status of potential ARARs may also be evaluated. However, in many circumstances these To-Be-Considered (TBCs) documents will be considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of cleanup for protection of human health or the environment.

9.2 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

EPA RI/FS guidance documentation calls for the identification of potential remedial action objectives (RAOs) for each contaminated medium. General response actions are then selected that best address the RAOs. Candidate technologies are also identified to meet the requirements of the general response actions. The process of technology identification also helps to specify data needed to conduct the later technical evaluations and to ensure data collection as early as possible during the RI activities. Early identification of potential technologies also helps determine whether treatability studies will be required. (The approach to conducting a Feasibility Study is discussed in Section 10.0. A list of RAOs, general response actions, and candidate technologies is presented in Table 9-7.) The technologies are subsequently assembled into remedial action alternatives that address site risks.

To the extent practicable, the EPA RI/FS guidance calls for developing a preliminary list of broadly

defined remedial alternatives which address site remediation to varying degrees and meet the criteria set forth in the NCP for the types of remedial alternatives which must be considered.

For source control actions, the FS will develop the following per the NCP:

- A no-action alternative shall developed.

- A range of alternatives in which treatment that reduces the toxicity, mobility, or volume of the hazardous substance is a principal element. As appropriate, this range should include an alternative that removes or destroys hazardous substances to the maximum extent feasible, eliminating or minimizing the need for long-term management.

- As appropriate, other alternatives, at a minimum, which treat the principal threats posed by the site but vary in the degree of treatment employed and the quantities and characteristics of the treatment residuals and in treated wastes that must be managed.

- One or more alternatives that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances through engineering controls and/or institutional control.

- One or more innovative treatment technologies for further consideration, if they appear feasible.

For groundwater response actions, a limited number of remedial alternatives should be developed that attain site-specific remediation levels within different restoration time periods utilizing one or more different technologies. A no-action alternative for groundwater response actions will also be developed.

Based on an evaluation of site-specific problems and the proposed cleanup criteria, lists of potentially feasible remedial alternatives/technologies have been developed for soil/sediment and groundwater, as presented in Tables 9-8 and 9-9. The remediation methods include both on-site in-situ and ex-situ remedies and include treatment technologies to permanently reduce toxicity, mobility, and volume to the maximum extent practicable. Some preliminary identification of data requirements to assess the effectiveness of the treatment technologies on site-specific contaminants are also identified in Tables 9-8 and 9-9.

10.0 TREATABILITY STUDY AND FEASIBILITY STUDY PLAN

This section describes the tasks associated with conducting treatability studies, pilot testing, and the Feasibility Study (FS) for the Melville North Landfill Site. An initial plan for conducting treatability studies is presented. A discussion of the FS process is also presented in this section.

10.1 TREATABILITY STUDY/PILOT TESTING PLAN

Currently, the Melville North Landfill Site is not adequately characterized to allow for the identification of applicable treatability studies. Treatability study and pilot testing may be appropriate for the Melville North Landfill Site. Initiation of the Feasibility Study process, specifically the initial development and screening of remedial technologies and alternatives will allow for a more focused application of such testing should it be deemed appropriate. The additional environmental sampling to be performed during the RI will provide further information on ambient or background conditions or the extent of contamination. This additional information, along with the preliminary scoping of remedial alternatives within the Feasibility Study process, will allow for a better definition of applicable technologies. Since treatability studies for certain technologies can be costly, it is essential to limit the number of technologies being considered prior to the initiation of such studies. As part of this task, HNUS project team members will meet with Navy/NETC-Newport representatives including Restoration Advisory Board (RAB) Members to discuss the need for treatability studies and potential scopes. The meeting will be scheduled once the preliminary Phase II analytical results are available and preliminary remedial alternative scoping activities have been completed.

This section also discusses preliminarily the nature of site contaminants and potential remedial technologies which may require treatability study/pilot testing to demonstrate their applicability and effectiveness. A review of Phase I RI analytical data and the results of the Phase I Risk Assessment with respect to chemical-specific, enforceable ARARs and acceptable risk levels has provided a preliminary indication of the types of contaminants which may require treatment at the Melville North Landfill site.

For soil contaminants, no enforceable chemical-specific ARARs have been identified. However, other state criteria including background levels, groundwater classification, proximity to surface water bodies, and Phase I RI data and risk assessment results will be evaluated to determine whether soils remediation is needed. Therefore, for this preliminary evaluation, the results of the Phase I Risk

Assessment were used to identify potential site contaminants requiring remediation. The Site soil contaminants detected at concentrations which contributed most to carcinogenic risk levels included arsenic and PAHs. Antimony and copper were both detected at levels in site soils which contributed the most to non-carcinogenic risks.

For site groundwater, aluminum, beryllium, cadmium, iron, manganese, and lead concentrations frequently exceeded MCLs. The following analytes/compounds were also detected at concentrations exceeding MCLs, although less frequently: chromium, nickel, xylene, benzene, ethylbenzene, PCBs, and 1,4-dichlorobenzene. At the Melville North Landfill site, estimated risks exceeded the acceptable risk levels associated with groundwater exposure/ingestion for arsenic. Analytes which were detected less frequently in groundwater at concentrations which result in carcinogenic or non-carcinogenic risks include beryllium, chromium, copper, mercury, thallium, vanadium, zinc, PAHs, 1,1-dichloroethene, trichloroethene, and vinyl chloride. However, it is uncertain at this time whether groundwater remediation will be necessary. Evaluation of the RI results and risk assessment results will be required to determine the need for groundwater remediation.

Based on this preliminary analysis, remedial technologies which offer inorganic treatment of soils and/or groundwater appear to be applicable to the Melville North Landfill Site. Treatability studies may be performed for technologies which are innovative and relatively unproven or for technologies which have a proven record but which require testing to assure that remedial action objectives can be achieved. Examples of soil treatment technologies which may be applicable to inorganic contaminants and which may require treatability study testing include: soil stabilization, solvent extraction, soil washing (separation), or in-situ vitrification. If groundwater remediation is necessary, after evaluation of ARARs and risk assessment results, treatment technologies would be identified and suspended. Examples of treatment technologies for inorganics in groundwater, if required, may include chemical precipitation, ion exchange, and filtration. Examples of groundwater treatment technologies, if required, which may be applicable to organic contaminants and which require treatability study testing include: biodegradation, air or steam stripping, enhanced oxidation, membrane microfiltration, and powdered activated carbon treatment (PACT™).

10.2 FEASIBILITY STUDY PLAN

The overall objective of the FS is to develop and evaluate remedial alternatives that will lead to the fulfillment of the remedial action objectives and remedial goals. The Feasibility Study (FS) will draw upon existing site characterization data, existing remedial treatment process data, existing treatability

study data, where available, and baseline risk assessment findings to evaluate potential remedial options. The methodology to be followed in conducting the FS will conform with the requirements of CERCLA, SARA, and the NCP. The Feasibility Study is based upon the U.S. Environmental Protection Agency (EPA)'s Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final (October 1988), which provides a basis for conducting the FS in accordance with the aforementioned requirements. As appropriate, other guidances may also be used: Remedial Action Costing Procedures Manual (1984); Compendium of Costs of Remedial Technologies at Hazardous Waste Sites (1985); A Guide to Selecting Superfund Remedial Actions, (April 1990); CERCLA Compliance with Other Laws Manual (Interim Draft) (EPA, 1988); and technology-specific guidance and evaluation documents. Should any of these documents be amended or if additional guidance becomes available, the RI/FS will be made consistent with and incorporate any such changes, additions, and/or amendments where feasible and practicable.

To date, the Confirmation Study and the Phase I Remedial Investigation (RI) activities have been conducted, providing an understanding of existing Site conditions. The Phase II RI will attempt to address data gaps and provide a more comprehensive understanding of the Site for the FS. The FS will include a systematic evaluation and screening of possible remedial technologies, development and evaluation of a focused range of comprehensive remedial alternatives, and will provide the basis for the selection of a recommended remedial alternative. The overall approach for conducting a Feasibility Study is depicted in Figure 10-1. Major components of an FS are described below.

For the purpose of the Work Plan, the following assumptions were made based on discussions with the Navy:

- The FS will address landfill materials (soils/wastes), groundwater, and wetlands
- No evaluation of off-shore sediments will be performed under this FS.
- The presumptive remedy for landfills may not be applicable for this Site.

The Feasibility Study will consist of these tasks:

- Identification and Screening of Technologies
- Development and Screening of Remedial Alternatives
- Remedial Alternatives Evaluation
- FS Report

10.2.1 Identification and Screening of Technologies

The preliminary remedial technology identification will use data collected during the Remedial Investigation and the results of the human health and ecological risk assessments to accomplish the following objectives:

- Develop and refine remedial action objectives and general response actions.
- Identify and screen applicable remedial technologies, including potential process options.
- Formulate remedial alternatives.
- Screen remedial alternatives, including recommendations for bench/pilot treatability studies.

Candidate remedial alternatives will be developed through an identification and screening process. This process consists of development of goals of remediation, identification of general categories of remedial actions (e.g., treatment, containment, etc.) to be considered, estimation of volumes or areas of media to which these general kinds of actions may be applied, identification of the technologies applicable to each of the general kinds of actions, and then the screening of these technologies on the basis of technical implementability. Each of these process steps is discussed in more detail below.

10.2.1.1 Development of Remedial Action Objectives and General Response Actions

Using data collected during the RI, remedial action objectives will be developed or refined that address substantial risks in the Site. Remedial action objectives consist of media-specific goals for protecting human health and the environment. Remedial action objectives will specify the following:

- Contaminants of concern
- Exposure routes and receptors
- Potentially acceptable contaminant levels or ranges of levels for each exposure route

Chemical- and location-specific ARARs and risk-based levels will also be used in determining the extent of site cleanup and in developing remedial action objectives.

General response actions describe media-specific measures that will satisfy the remedial action objectives including consideration of treatment, containment, excavation, extraction, disposal, and institutional actions, or a combination of these measures. This task will also include an initial determination of areas or volumes of media to which the general response actions might be applied. The subsequent development of remedial alternatives may either link groups of areas for similar remedial action or retain separate areas, each with distinct remediation requirements.

Estimates of the volumes and areas of contaminated media to which the general response actions apply will be developed. Estimates will be based upon the data defining the nature and extent of site contamination, as well as the site geology and hydrogeology.

Once preliminary remedial action objectives and general response actions have been identified, a meeting will be scheduled with the Navy prior to finalizing all decisions and selections.

10.2.1.2 Identification and Screening Remedial Technologies and Process Options

Based on remedial action objectives and general response actions, a list of applicable remedial technologies and process options will be prepared. Both source control and groundwater response technologies will be identified for the Site, as necessary. Typically, broad technology types may be identified for each general response action; several technology process options may exist within each technology type. The applicability of different process options will be assessed, based on site conditions and remedial action objectives.

A preliminary list of applicable technologies for groundwater remediation at the Melville North Landfill site has been identified based on information gathered during previous investigations and is presented in Table 9-7.

The technology types can be further evaluated for each specific area after additional field data are collected and remedial action objectives reviewed.

Section 9.0 of the Draft Phase II RI/FS Work Plan presented the initial identification of some technology types and described the general purpose of the potential remedial response in light of the current understanding of environmental contamination. Additional technology types may be considered on the nature and extent of contaminants are better defined.

Remedial technologies will be screened for effectiveness and implementability, with an emphasis on determining site or waste characteristics that might limit effectiveness or implementability at the site. Other considerations include implementability in terms of technical feasibility, demonstrated performance, treatment availability and contractors and equipment, process residuals, and storage and disposal services. The reasons for eliminating technologies in this stage will be documented in the FS report. On the basis of the screening evaluation, a representative process option will be chosen for each technology type. This representative process option is then used in the development and evaluation of remedial alternatives. A meeting will be held with Navy to review results of the technology screening.

10.2.2 Development and Screening of Alternatives

After remedial technologies have been defined and screened, remedial action alternatives will be developed. These alternatives will be categorized as source control (soil/waste materials), groundwater response, surface water response, and sediment remediation alternatives. The purpose of source control alternatives is to prevent or minimize migration of hazardous substances from the source(s). Groundwater and surface water response alternatives typically address aqueous contaminants water which have migrated downgradient or downstream from the Site.

Development of remedial action alternatives will be governed by remedial action objectives, risk considerations, and other site remediation requirements. Following the guidelines in CERCLA/SARA and the NCP, a range of treatment alternatives will be developed, based on the need for long-term management and the ability of each alternative to reduce the mobility, toxicity, or volume of contaminants. A containment option involving little or no treatment may be developed as EPA determines appropriate. A No-Action alternative will also be developed.

At this stage in the FS, each alternative will be described in sufficient detail to include the location of areas to be excavated, treated, or contained; approximate volumes of soil and/or groundwater to be addressed; and potential locations for interceptor trenches or discharges to surface water. These descriptions attempt to demonstrate the rationale behind the assembly of general response actions into remedial technologies and remedial alternatives.

The list of remedial action alternatives may be screened to narrow the number of alternatives for subsequent detailed analysis but will still preserve a range of treatment options. However, this step may not be required if the formulation of alternatives included consideration of site-specific conditions

and factors. The evaluations used in this screening are not intended to substitute or supplement the detailed analysis of each alternative to be conducted in the Remedial Alternatives Evaluation.

Should alternative screening be required, the three following primary activities will be completed:

- Alternatives will be further refined to provide information for quantifying areas and volumes to be remediated and to size process options.

- Alternatives will be evaluated on a general basis with regard to effectiveness, implementability, and cost.

- Based on this evaluation, alternatives will be eliminated from further consideration or retained for detailed analysis.

The screening is accomplished by considering the alternatives in terms of effectiveness, implementability, and cost factors. Cost is important when comparing alternatives that provide similar results. However, costs may not be used to discriminate between treatment and non-treatment alternatives. The list of alternatives will be narrowed by eliminating:

- Alternatives that are not technically reliable, do not effectively and adequately protect human health and the environment, or do not attain ARARs.

- Alternatives that are not technically feasible or available, or require significant institutional or administrative effort during implementation or operation.

- Alternatives that are significantly more costly than other alternatives, but fail to provide greater environmental/public health benefits, reliability, or effectiveness.

The rationale for eliminating alternatives at this stage will be documented in the FS report. Remedial alternatives that contain innovative technologies will be carried through the screening if they offer the potential for better treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs than demonstrated technologies.

10.2.3 Remedial Alternatives Evaluation

The detailed analysis of alternatives (remedial alternatives evaluation) consists of several components:

- Further definition of each alternative, including preliminary design calculations, process flow diagrams, sizing of key components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning the alternative

- Assessment and summary of each alternative against evaluation criteria

- Comparative analysis among alternatives to assess the performance of an alternative relative to each evaluation criterion

Remedial alternatives passing the alternative screening process will be further evaluated and compared, as required in both the NCP and CERCLA, as amended.

Evaluation criteria developed to address CERCLA requirements includes both technical and administrative considerations. These criteria will serve as the basis for the detailed analysis in the CTO 172 FS. These criteria will also assist in comparing alternatives; subsequently they will help in selecting an appropriate remedial action. The evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State (Support Agency) acceptance
- Community acceptance

Of the nine evaluation criteria, only the first seven will be evaluated in detail in the FS. State and community acceptance criteria will not be evaluated or included in the FS report, since these items will be evaluated in the Record of Decision (ROD) following the public comment period. The first seven evaluation criteria are summarized as follows:

Overall Protection of Human Health and the Environment - This criterion provides an overview of whether the alternative is protective of human health and the environment. It is based on other evaluation criteria, including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The way in which an alternative addresses the previously identified site risks through the use of treatment, engineering, or institutional controls is evaluated. In addition, consideration is given to any short-term risks and/or cross-media impacts that may be associated with the implementation of an alternative.

Compliance with ARARs - This evaluation criterion addresses the manner in which the alternative complies with contaminant-specific, location-specific, and action-specific ARARs. The ARARs that apply to each alternative will be identified, and the manner in which the alternative meets the requirements of the ARAR will be described. When an ARAR will not be met, justification for a waiver that satisfies the requirements of CERCLA will be presented.

Long-Term Effectiveness and Permanence - This criterion addresses the degree of long-term risk that will be posed by treatment residuals, contaminated media, and/or untreated wastes remaining at the site after remedial response objectives have been met and the effectiveness and reliability of controls, if any, used to manage these risks.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This element of the detailed analysis focuses on the extent to which the alternative employs treatment technologies that permanently or significantly reduce toxicity, mobility, or volume of contaminated media as a principal element. The degree of treatment provided by the alternative, the irreversibility of the treatment, and the type and quantity of residuals remaining after treatment are discussed.

Short-Term Effectiveness - Short-term effectiveness relates to the human health and/or environmental impacts which result during the construction and implementation phases of the remediation, and the degree to which such impacts are controlled. This evaluation will encompass short-term impacts on the surrounding community, occupational impacts on workers engaged in construction and/or implementation activities, and short-term impacts on the environment. The time period required to meet remedial action objectives will also be estimated.

Implementability - This criterion considers the technical and administrative feasibility of implementing the alternative. As in the preliminary alternative screening, the technical feasibility of construction and operation, the administrative feasibility of obtaining permits and coordination with regulatory agencies,

and the availability of the remedial services, materials, and personnel experienced in providing the services will be considered.

Cost - Estimates of the magnitude and timing of direct capital, indirect capital, and O&M costs will be made and future costs will be discounted to the present in order to calculate a present worth cost estimate for each alternative. The detailed and comprehensive information base available from the RI are expected to enable the formulation of cost estimates that fall within a range of accuracy of +50 percent to -30 percent. Factors which may limit the accuracy of the cost estimates, such as conflicting field data or uncertainties in the time required to reach remedial objectives, will be identified. A cost sensitivity analysis will be performed in which the impact of variations in design assumptions will be evaluated. Where there is sufficient uncertainty associated with the basic assumptions used to develop an individual cost, the assumptions will be varied and the overall impact on the total estimated cost will be calculated.

Potential future private ownership of the Site will addressed through the evaluation of the following criteria: long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; short-term effectiveness, and implementability.

Upon completion of the individual analyses of alternatives, a comparative analysis of alternatives will be conducted. Thus the relative performance of each alternative in relation to each of the seven evaluation criteria will be assessed. In this way the major tradeoffs to be weighed in the alternative selection process will be identified.

10.2.4 Draft FS Report

A draft report will be prepared presenting the results of the Feasibility Study. A proposed outline for the Feasibility Study report is presented in Table 10-1. The following interim deliverables shall be provided to the Navy prior to the submittal of the Draft FS report:

- Draft ARARs
- A list of draft remedial action objectives and general response actions
- A summary of the identification of potentially applicable technologies
- A list of proposed alternatives

Twenty-two (22) copies of the Draft FS report will be distributed as directed in the SOW. As necessary, up to two meetings will be held with the Navy and the RI DEM to discuss the draft FS report.

TABLES

TABLE 4-1
SUMMARY OF SAMPLING AND ANALYSES
PHASE II REMEDIAL INVESTIGATION/ FEASABILITY STUDY
MELVILLE NORTH LANDFILL
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

SAMPLE EVENT	ESTIMATED NUMBER OF SAMPLES (1)	SAMPLE ANALYSES	ANALYTICAL METHOD (2)
Surface Soils	9	TCL Volatile Organic Compounds	CLP SOW 3/90, w/revisions
	9	TCL Base Neutral and Acid Extractable Compounds	CLP SOW 3/90, w/revisions
	9	TCL Pesticide/PCBs	CLP SOW 3/90, w/revisions
	9	Total TAL Metals and Cyanide	CLP SOW 3/90, w/revisions
Subsurface Soils	57 (3)	TCL Volatile Organic Compounds	CLP SOW 3/90, w/revisions
	57	TCL Base Neutral and Acid Extractable Compounds	CLP SOW 3/90, w/revisions
	57	TCL Pesticide/PCBs	CLP SOW 3/90, w/revisions
	57	Total TAL Metals and Cyanide	CLP SOW 3/90, w/revisions
	10	Total Organic Carbon	Lloyd Kahn Method
	10	Cation Exchange Capacity	SW-846 Method 9080
	10	Grain Size Determination	ASTM Method D-422-63
Groundwater	18	TCL Volatile Organic Compounds	CLP SOW 3/90, w/revisions
	18	TCL Base Neutral and Acid Extractable Compounds	CLP SOW 3/90, w/revisions
	18	TCL Pesticide/PCBs	CLP SOW 3/90, w/revisions
	18	Total TAL Metals and Cyanide	CLP SOW 3/90, w/revisions
	18	Total Chloride	EPA 325.2
	5	Biological Oxygen Demand	EPA 405.1
	5	Chemical Oxygen Demand	EPA 410.3
	5	Total Suspended Solids	EPA 160.2
	5	TAL Metals (Dissolved)	CLP SOW 3/90, w/revisions
Sediment	3	TCL Volatile Organic Compounds	CLP SOW 3/90, w/revisions
	3	TCL Base Neutral and Acid Extractable Compounds	CLP SOW 3/90, w/revisions
	3	TCL Pesticide/PCBs	CLP SOW 3/90, w/revisions
	3	Total TAL Metals	CLP SOW 3/90, w/revisions
	3	Total Organic Carbon	Lloyd Kahn Method
	3	Grain Size Determination	ASTM Method D-422-63
	3	Acid Volatile Sulfides	No Method Number (4)
	3	Simultaneously Extractable Metals	No Method Number

Notes:

(1) Number of samples does not include QA/QC samples (see Table 4-3).
(2) NEESA QC Level D will be used for all samples.
(3) Estimate based on the collection of three samples from each of the eleven soil borings; three samples each from four onsite well borings; two samples each from five onsite wells; and one sample each from two offsite wells.
(4) Draft method based on the following document: Determination of Acid Volatile Sulfide and Selected Simultaneously Extractable Metals in Sediment, Allen, Fu, et al., 1991.

TCL – Target Compound List
TAL – Target Analyte List
PCBs – Polychlorinated biphenyls
SOW – Statement of Work
CLP – Contract Laboratory Program
ASTM – American Society for Testing Materials

TABLE 4–2
SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
PHASE II REMEDIAL INVESTIGATION/ FEASABILITY STUDY
MELVILLE NORTH LANDFILL
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

SAMPLE MEDIUM	SAMPLE ANALYSES	SAMPLE CONTAINER	MINIMUM VOLUME	PRESERVATIVE	HOLDING TIME (1)
Surface Soils	TCL Volatile Organic Compounds	1 – 4 oz jar	1 – 4 oz jar	Cool to 4° C	14 Days
	TCL Base Neutral and Acid Extractable Compounds	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	TCL Pesticide/PCBs	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	Total TAL Metals, Cyanide	1 – 8 oz jar	1 – 4 oz jar	Cool to 4° C	6 Months / 14 Days
Subsurface Soils	TCL Volatile Organic Compounds	1 – 4 oz jar	1 – 4 oz jar	Cool to 4° C	14 Days
	TCL Base Neutral and Acid Extractable Compounds	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	TCL Pesticide/PCBs	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	Total TAL Metals, Cyanide	1 – 8 oz jar	1 – 4 oz jar	Cool to 4° C	6 Months / 14 Days
	Total Organic Carbon	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	14 Days
	Cation Exchange Capacity	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	None
	Grain Size Determination	1 – 8 oz jar	1 – 8 oz jar	None	None
Groundwater	TCL Volatile Organic Compounds	2 – 40 ml VOA vials	1 – 40 ml VOA vial	Hydrochloric Acid (HCL) to pH < 2/ Cool to 4° C	14 Days
	TCL Base Neutral and Acid Extractable Compounds	1 – 1 liter amber bottle	1 – 1 liter amber bottle	Cool to 4° C	7 Days (extraction) (2)
	TCL Pesticide/PCBs	1 – 1 liter amber bottle	1 – 1 liter amber bottle	Cool to 4° C	7 Days (extraction) (2)
	Total TAL Metals	1 – 500 ml plastic bottle	300 ml	Nitric acid (HN03) to pH < 2/Cool to 4° C	6 Months
	TAL Cyanide	1 – 1 liter plastic bottle	500 ml	Sodium Hydroxide (NaOH) to pH> 12/Cool to 4°C	14 Days
	Total Chloride	1 – 250 ml plastic bottle	50 ml	None	28 Days
	Biological Oxygen Demand	1 – 1 liter plastic bottle	500 ml	Cool to 4° C	48 Hours
	Chemical Oxygen Demand	1 – 1 liter plastic bottle	500 ml	Cool to 4° C	28 Days
	Total Suspended Solids	1 – 1 liter plastic bottle	500 ml	Cool to 4° C	7 Days
	TAL Metals (Dissolved)	1 – 500 ml plastic bottle	300 ml	Nitric acid (HN03) to pH <2/Cool to 4° C	6 Months
Sediment	TCL Volatile Organic Compounds	1 – 4 oz jar	1 – 4 oz jar	Cool to 4° C	14 Days
	TCL Base Neutral and Acid Extractable Compounds	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	TCL Pesticide/PCBs	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	7 Days (extraction) (2)
	Total TAL Metals	1 – 8 oz jar	1 – 4 oz jar	Cool to 4° C	6 Months
	Total Organic Carbon	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	14 Days
	Grain Size Determination	1 – 8 oz jar	1 – 8 oz jar	None	None
	Acid Volatile Sulfides	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	None
	Simultaneously Extractable Metals	1 – 8 oz jar	1 – 8 oz jar	Cool to 4° C	None

Notes:

(1) Holding times are calculated from date of collection.
(2) Holding times for the TCL Base Neutral Acid and Extractable Compounds as well as the Pesticides/PCBs are based on time of extraction; analysis holding time is an additional 40 days.

TCL – Target Compound List
TAL – Target Analyte List
PCBs – Polychlorinated biphenyls

TABLE 4-3
FIELD QUALITY CONTROL SAMPLE SUMMARY
PHASE II REMEDIAL INVESTIGATION/ FEASABILITY STUDY
MELVILLE NORTH LANDFILL
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

SAMPLE EVENT	SAMPLE ANALYSES	ESTIMATED NUMBER OF SAMPLES	FIELD DUPLICATES (1)	FIELD BLANKS (2)	TRIP BLANKS (3)	RINSATE BLANKS (4)	TOTAL QC SAMPLES
Surface Soils	TCL Volatile Organic Compounds	9	1	0	1	1	3
	TCL Base Neutral and Acid Extractable Compounds	9	1	0	---	1	2
	TCL Pesticide/PCBs	9	1	0	---	1	2
	Total TAL Metals and Cyanide	9	1	0	---	1	2
Subsurface Soils	TCL Volatile Organic Compounds	57 (3)	6	2	10	5	23
	TCL Base Neutral and Acid Extractable Compounds	57	6	2	---	5	13
	TCL Pesticide/PCBs	57	6	2	---	5	13
	Total TAL Metals and Cyanide	57	6	2	---	5	13
	Total Organic Carbon	10	1	---	---	---	1
	Cation Exchange Capacity	10	1	---	---	---	1
	Grain Size Determination	10	1	---	---	---	1
Groundwater	TCL Volatile Organic Compounds	18	2	---	5	3	10
	TCL Base Neutral and Acid Extractable Compounds	18	2	---	---	3	5
	TCL Pesticide/PCBs	18	2	---	---	3	5
	Total TAL Metals and Cyanide	18	2	---	---	3	5
	Total Chloride	18	2	---	---	---	2
	Biological Oxygen Demand	5	1	---	---	---	1
	Chemical Oxygen Demand	5	1	---	---	---	1
	Total Suspended Solids	5	1	---	---	---	1
	TAL Metals (Dissolved)	5	1	---	---	3	4
Sediment	TCL Volatile Organic Compounds	3	1	---	1	1	3
	TCL Base Neutral and Acid Extractable Compounds	3	1	---	---	1	2
	TCL Pesticide/PCBs	3	1	---	---	1	2
	Total TAL Metals	3	1	---	---	1	2
	Total Organic Carbon	3	1	---	---	---	1
	Grain Size Determination	3	1	---	---	---	1
	Acid Volatile Sulfides	3	1	---	---	---	1
	Simultaneously Extractable Metals	3	1	---	---	---	1

Notes:

(1) Field Duplicates are to be collected at 10% frequency.
(2) Field Blanks consist of source water used for decontamination and steam cleaning (1 per water source per sampling event).
(3) One Trip Blank will accompany each cooler containing samples to be analyzed for VOCs.
(4) One Rinsate Blank will be collected for every 20 samples or per day per matrix, whichever is greater.
50% of samples (one from every other day) will be analyzed to confirm adequacy of decontamination procedures.

TCL – Target Compound List
TAL – Target Analyte List
PCBs – Polychlorinated biphenyls

TABLE 4-4
SUMMARY OF SOIL BORING AND MONITORING WELL INSTALLATION
MELVILLE NORTH LANDFILL RI/FS

BORING NUMBER	TOTAL DEPTH (FT)	DRILLING METHOD	SPLIT SPOON SAMPLES	ESTIMATED NUMBER OF SOIL SAMPLES COLLECTED	ESTIMATED NUMBER OF SOIL SAMPLES ANALYZED(d)	ROCK CORING (FT)	CONTRUCT WELL
B-14	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-15	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-16	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-17	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-18	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-19	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-20	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-21	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-22	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-23	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
B-24	20	HSA(a)	CONTINUOUS	10	3(e)	0	NO
MW-5R	30	CSG(b)	CTW(c)	6	1(f)	10	YES(g)
MW-6S	20	HSA(a)	NONE	NONE	NONE	0	YES(g)
MW-6R	30	CSG(b)	CTW(c)	6	1(f)	10	YES(g)
MW-7S	20	HSA(a)	CONTINUOUS	10	3(e)	0	YES(g)
MW-8S	20	HSA(a)	CONTINUOUS	10	3(e)	0	YES(g)
MW-9S	20	HSA(a)	CONTINUOUS	10	3(e)	0	YES(g)
MW-10S	20	HSA(a)	NONE	NONE	NONE	0	YES(g)
MW-10R	30	CSG(b)	CONTINUOUS	10	3(e)	10	YES(g)
MW-11S	20	HSA(a)	CONTINUOUS	10	3(e)	0	YES(g)
MW-12S	20	HSA(a)	CONTINUOUS	10	3(e)	0	YES(g)
MW-13S	20	HSA(a)	NONE	NONE	NONE	0	YES(g)
MW-13R	30	CSG(b)	CONTINUOUS	10	2(h)	10	YES(g)
MW-14S	20	HSA(a)	CONTINUOUS	10	2(h)	0	YES(g)

(a) HSA - hollow stem auger
(b) CGS - casing advance by either spun casing or drive & wash method
(c) CTW - continuous to water table then at 5 foot intervals to bedrock
(d) See Table 4-1 for samples (including QC) to be collected
(e) See Section 4.2.6.2. Third soil sample to be collected only visible contamination present below fill or water table.
(f) Surface soil sample (0-1' interval) to be collected from background locations
(g) See Sections 4.2.7.2 for overburden and 4.2.7.3 for bedrock construction details
(h) Wells to be installed beyond known extent of fill. Only two soil samples are anticipated.

TABLE 4-5
SUMMARY OF GROUNDWATER SAMPLING
MELVILLE NORTH LANDFILL RI/FS

WELL NUMBER	TCL/TAL AND CHLORIDE SAMPLES(a)	OTHER ANALYSES(b)
MW-1	YES	NO
MW-2	YES	NO
MW-3	YES	NO
MW-4	YES	NO
MW-5	YES	YES
MW-5R	YES	NO
MW-6S	YES	NO
MW-6R	YES	NO
MW-7S	YES	NO
MW-8S	YES	NO
MW-9S	YES	NO
MW-10S	YES	YES
MW-10R	YES	YES
MW-11S	YES	NO
MW-12S	YES	NO
MW-13S	YES	YES
MW-13R	YES	YES
MW-14S	YES	NO

(a) See Section 4.2.8 for task description. SeeTables 4-1 & 4-3 for samples (including QC) to be collected
(b) See end of Section 4.2.8.2. See Tables 4-1 & 4-3 for other groundwater samples (including QC) to be collected

TABLE 4-6
SUMMARY OF SURFACE SOIL & SEDIMENT SAMPLING
MELVILLE NORTH LANDFILL RI/FS

SAMPLE NUMBER	TCL/TAL AND CHLORIDE SAMPLES(a)	OTHER ANALYSES(b)
SS-16(c)	YES	NO
SS-17	YES	NO
SS-18	YES	NO
SS-19	YES	NO
SS-22	YES	NO
SS-23	YES	NO
SS-24	YES	NO
SS-25	YES	NO
SS-26	YES	NO
SD-11(d)	YES	YES
SD-12	YES	YES
SD-13	YES	YES

(a) See Section 4.2.5 for task description and Figure 4-4 for sample locations. See Tables 4-1 & 4-3 for samples (including QC) to be collected.
(b) See Section 4.2.4.7 for task description and Figure 4-4 for sample locations. See ables 4-1 & 4-3 other sediment samples (including QC) to be collected.
(c) SS = Surface Soil sample
(d) SD = Sediment sample

TABLE 6-1
REMEDIAL INVESTIGATION REPORT FORMAT

EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1	Purpose of Report
1.2	Site Background
1.2.1	Site Description
1.2.2	Site History
1.2.3	Previous Investigations
1.3	Report Organization

2.0 STUDY AREA INVESTIGATION

2.1	Includes field activities associated with site characterization. These may include physical and chemical monitoring of some, but not necessarily all, of the following:
2.1.1	Surface Features (topographic mapping, etc.) (natural and manmade features)
2.1.2	Contaminant Source Investigations
2.1.3	Meteorological Investigations
2.1.4	Surface Water and Sediment Investigations
2.1.5	Geological Investigations
2.1.6	Soil and Vadose Zone Investigations
2.1.7	Groundwater Investigations

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.1	Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
3.1.1	Surface Features
3.1.2	Geology
3.1.3	Soils
3.1.4	Hydrogeology

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1	Presents the results of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the media
4.1.1	Sources (lagoons, sludges, tanks, etc.)
4.1.2	Soils and Vadose Zone
4.1.3	Groundwater
4.1.4	Surface Water and Sediments
4.1.5	Air

5.0 CONTAMINANT FATE AND TRANSPORT

5.1	Potential Routes of Migration (i.e., Air, Groundwater, etc.)
5.2	Contaminant Persistence
5.2.1	If they are applicable (i.e., for organic contaminants), describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest.

TABLE 6-1
REMEDIAL INVESTIGATION REPORT FORMAT
PAGE TWO

5.3	Contaminant Migration
5.3.1	Discuss factors affecting contaminant migration for the media of importance (sorption onto soils, solubility in water, movement of groundwater, etc.)
5.3.2	Discuss modeling methods and results, if applicable.
6.0	**BASELINE HUMAN HEALTH RISK ASSESSMENT**
6.1	Introduction
6.2	Hazard Identification
6.2.1	Selection of Chemicals of Concern
6.2.2	Toxicity Profiles
6.3	Dose Response Assessment
6.3.1	Toxicity Criteria
6.3.2	Criteria/Standards
6.4	Exposure Assessment
6.4.1	Sources of Contamination
6.4.2	Contaminant Transport and Migration
6.4.3	Receptor Identification and Exposure Routes
6.5	Risk Characterization
6.5.1	Estimate of Carcinogenic Risks
6.5.2	Estimation of Non-carcinogenic Risks
6.5.3	Risk Assessment Results
7.0	**ECOLOGICAL RISK ASSESSMENT**
7.1	Site Description and Potential Receptors
7.1.1	Characteristics of the Study Area
7.1.2	Habitats and Receptor Groups
7.1.3	Nature and Extent of Contamination
7.2	Selection of Contaminants and Receptors of Concern
7.2.1	Selection of Contaminants of Concern
7.2.2	Selection of Indicator Species
7.2.3	Ecological Effects of Concern
7.3	Exposure Assessment
7.3.1	Sources of Contamination
7.3.2	Fate and Transport Analysis
7.3.3	Surface Water Exposure Pathway
7.3.4	Sediment Exposure Pathway
7.3.5	Soil Exposure Assessment
7.3.6	Uncertainty Analysis
7.4	Ecological Effects Assessment
7.4.1	Effects of Contamination of Concern
7.4.2	Benchmark Toxicity Values
7.4.3	Uncertainty Analysis
7.5	Risk Characterization
7.5.1	Surface Water
7.5.2	Sediment
7.5.3	Soil
7.5.4	Uncertainty Analysis
7.6	Conclusions

TABLE 6-1
REMEDIAL INVESTIGATION REPORT FORMAT
PAGE THREE

8.0	**SUMMARY AND CONCLUSIONS**	
	8.1	Summary
	8.1.1	Nature and Extent of Contamination
	8.1.2	Fate and Transport
	8.1.3	Base Line Human Health Risk Assessment
	8.1.4	Ecological Risk Assessment
	8.2	Conclusions
	8.2.1	Data Limitations and Recommendations for Future Work
	8.2.2	Recommended Remedial Action Objectives

TABLE 6-2
FEASIBILITY STUDY REPORT FORMAT

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 Purpose and Organization of Report
- 1.2 Background and Information (Summarized from RI Report)
- 1.2.1 Site Description
- 1.2.2 Site History
- 1.2.3 Nature and Extent of Contamination
- 1.2.4 Contaminant Fate and Transport
- 1.2.5 Baseline Risk Assessment

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

- 2.1 Introduction
- 2.2 Remedial Action Objectives -- (Presents the development of remedial action objectives for each medium of interest, i.e., soil, groundwater, etc.) For each medium, the following would be discussed:
  - Contaminants of interest
  - Allowable exposure based on risk assessment
  - Allowable exposure based on ARARs
  - Allowable concentrations based on protection of groundwater
  - Development of remedial action objectives
- 2.3 General Response Actions -- (For each medium of interest, describes the estimation of areas or volumes to which treatment, or containment technologies may be applied)
- 2.4 Identification and Screening of Technology Types and Process Options -- (For each medium of interest, describes:
- 2.4.1 Identification and Screening of Technologies
- 2.4.2 Evaluation of Technologies and Selection of Representative Technologies

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

- 3.1 Development of Alternatives -- (Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.)
- 3.2 Screening of Alternatives -- (If there are only a limited number of viable alternatives, screening of alternatives could be eliminated)
- 3.2.1 Introduction
- 3.2.2 Alternative 1
- 3.2.2.1 Description

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	3.2.2.2	Evaluation - Effectiveness - Implementability - Cost
	3.2.3	Alternative 2
	3.2.3.1	Description
	3.2.3.2	Evaluation
	3.2.4	Alternative 3
	3.2.5	Summary of Screening
4.0	**DETAILED ANALYSIS OF ALTERNATIVES**	
	4.1	Introduction
	4.2	Individual Analysis of Alternatives
	4.2.1	Alternative 1
	4.2.1.1	Description
	4.2.1.2	Assessment - Overall Protection - Compliance with ARARs - Long-Term Effectiveness - Reduction of Mobility, Toxicity, or Volume through Treatment - Short-Term Effectiveness - Implementability - Cost - State Acceptance (to be finalized in ROD) - Community Acceptance (to be finalized in ROD)
	4.2.2	Alternative 2
	4.2.2.1	Description
	4.2.2.2	Assessment
	4.2.3	Alternative 3
	4.3	Comparative Analysis
	4.3.1	Overall Protection
	4.3.2	Compliance with ARARs
	4.3.3	Long-Term Effectiveness and Permanence
	4.3.4	Reduction of Toxicity, Mobility, or Volume through Treatment
	4.3.5	Short-Term Effectiveness
	4.3.7	Cost
	4.3.8	State Acceptance (to be finalized in ROD)
	4.3.9	Community Acceptance (to be finalized in ROD)

BIBLIOGRAPHY

APPENDICES

TABLE 9-1
POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
GROUNDWATER				
Federal Regulatory Requirements	Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR 141.11-141.16)	To Be Evaluated	MCLs have been promulgated for a number of common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies. When an aquifer beneath a site is used for private drinking water supply and is a potential source for public water supply MCLs are considered relevant and appropriate.	The risks to human health due to consumption of groundwater may be assessed and concentrations of concern may be compared to the MCLs. MCLs may be used in determining clean-up levels for the aquifer.
	RCRA - Groundwater Protection Standard (40 CFR 264.94)	To Be Evaluated	The RCRA groundwater protection standard is established for groundwater monitoring of RCRA permitted treatment, storage or disposal facilities. The standard is set at either an existing or proposed RCRA-MCL, background concentration, or an alternate concentration limit (ACL) protective of human health and the environment.	RCRA-MCLs may be used or ACLs may be developed to identify levels of contamination in the aquifer above which human health and the environment are at risk and to provide an indicator when corrective action is necessary.
Criteria Advisories and Guidance	EPA Risk Reference Doses (RfDs)	To Be Evaluated	RfDs are dose levels developed by EPA for non-carcinogenic effects.	EPA RfDs are used to assess health risks due to exposure to non-carcinogenic contaminants present at the site. RfDs may also be used in the development of acceptable contaminant concentrations.
	EPA Carcinogen Assessment Group Potency Factors	To Be Evaluated	EPA Carcinogenic Potency Factors are used to compute the individual incremental cancer risk resulting from exposure to carcinogens.	These factors are used to assess health risks from carcinogens present at the site. These factors may also be used in the development of acceptable contaminant concentrations.
	EPA Health Advisories and Acceptable Intake Health Assessment Documents.	To Be Evaluated	Intended for use in qualitative human health evaluation of remedial alternatives.	These advisories and health assessment documents are used in assessing health risks from ingesting groundwater at the site.
	EPA Groundwater Protection Strategy	To Be Evaluated	Provides classification and restoration goals for groundwater based on its vulnerability, use, and value.	This strategy may be considered in conjunction with the Federal SDWA and Rhode Island Requirements in order to determine groundwater cleanup levels.

TABLE 9-1
POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
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AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Criteria Advisories and Guidance (con't)	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50 and 141.51)	To Be Evaluated	MCLGs are health-based limits and do not consider cost or feasibility. As health goals, MCLGs are established at levels at which no known or anticipated adverse effects on the health of persons occur and which allow for an adequate margin of safety.	Non-zero MCLGs may be used as clean-up levels if conditions at the site justify setting cleanup levels lower than MCLs.
SURFACE WATER				
Federal Regulatory Requirements	Clean Water Act Effluent Discharge Limitations (40 CFR 401.15)	To Be Evaluated	Regulates the discharge of contaminants from an industrial point source.	Remedial Alternatives that discharge to area surface waters are subject to these requirements.
Criteria Advisories and Guidance	CWA Ambient Water Quality Criteria (AWQC)	To Be Evaluated	AWQC are health-based criteria that have been developed for 95 carcinogenic and non-carcinogenic compounds.	AWQC can be used to characterize human health risks associated with either ingestion of water or consumption of aquatic organisms, and to set surface water discharge limits. Because the surface water at this site is not used as a drinking water source, the AWQC are considered in development of cleanup levels to protect aquatic organisms from contaminant exposure and to protect human health from consuming contaminated biota.
SOILS AND SEDIMENTS				
Criteria Advisories and Guidance	TSCA PCB Spill Clean-up Policy (40 CFR 761)	To Be Evaluated	This policy applies to recent PCB spills and establishes clean-up levels for three types of sites	These standards may be used as guidelines for soil cleanup at the site if PCB contamination must be addressed.
	OSWER Directive No. 9355.4-01 (Aug 1990). Guidance on Remedial Actions for Superfund Sites with PCB Contamination	To Be Evaluated	This guidance identifies soil action levels for residential (1 mg/kg) and industrial (10 mg/kg) land uses that would be protective of human health and result in risk levels that are within the 10^{-4} to 10^{-6} range.	The action levels identified may be used to develop site-specific soil preliminary remediation goals.
	Sediment Quality Criteria (SQC)	To Be Evaluated	The health-based criteria pertain to certain contaminants in sediment.	SQC may be used to characterize risks to aquatic organisms because of contaminant concentrations in sediments.

TABLE 9-1
POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
PAGE THREE

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
SOILS AND SEDIMENTS (con't)				
Criteria Advisories and Guidance	EPA Risk Reference Doses (RfDs)	To Be Evaluated	RfDs are dose levels developed by EPA for non-carcinogenic effects.	EPA RfDs were used to assess health risks due to exposure to non-carcinogenic contaminants present at the site. RfDs may be used in the development of acceptable contaminant concentrations.
	EPA Carcinogen Assessment Group Potency Factors	To Be Evaluated	EPA Carcinogenic Potency Factors are used to compute the individual incremental cancer risk resulting from exposure to carcinogens.	These factors were used to assess health risks from carcinogens present at the site. These factors may be used in the development of acceptable contaminant concentrations.
	EPA Health Advisories and Acceptable Intake Health Assessment Documents.	To Be Evaluated	Intended for use in qualitative human health evaluation of remedial alternatives.	These advisories and health assessment documents were used in assessing risks from ingesting contaminated media at the site.
AIR				
Federal Regulatory Requirements	CAA-State Implementation Plan Emission Standards (40 CFR 50)	To Be Evaluated	Emission standards designed to attain National Ambient Air Quality Standards (NAAQS)	State Implementation Plan requirements are enforceable ARARs and must be attained.
	CAA-National Emissions Standards for Hazardous Air Pollutants (40 CFR 61)	To Be Evaluated	Establishes Emission standards for Hazardous Air Pollutants for which no air quality standards exist.	These standards would control the air emission of hazardous air pollutants from treatment processes.
	CAA - New Source Performance Standards (NSPS)	To Be Evaluated	Establishes emissions limitations for new sources.	The standards address treatment actions which emit air pollutants.

TABLE 9-2
POTENTIAL STATE CHEMICAL-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
GROUNDWATER				
State Regulatory Requirements	RI Ground Water Protection Act, Public Drinking Water Regulations (RIGL, Title 46, Chapter 13)	To Be Evaluated	Establishes provisions for the protection and management of potable drinking waters, including the development of groundwater classifications and associated standards which specify maximum contaminant levels for each classification.	Potential ARARs due to the presence of contaminants in groundwater.
SURFACE WATER				
State Regulatory Requirements	RI Water Pollution Control Law, Water Quality Standards (RIGL, Title 46, Chapter 12)	To Be Evaluated	Establishes water use classification and water criteria for all waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	Potential ARARs due to the potential presence of contaminants in surface water.
SOILS				
Criteria Advisories and Guidance	RIDEM, Soil Cleanup Levels (Guidance)	To Be Evaluated	Establishes soil cleanup levels for PCBs.	Potential ARAR due to presence of PCBs in soils.
AIR				
State Regulatory Requirements	RI Clean Air Act, Air Pollution Control Regulation Standards (RIGL, Title 23, Chapter 23)	To Be Evaluated	Establishes maximum ambient levels for criteria pollutants.	Potential ARARs for alternatives involving treatment actions which emit criteria pollutants.

TABLE 9-3
POTENTIAL FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
WETLANDS/FLOODPLAINS				
Federal Regulatory Requirements	Clean Water Act (CWA) 404b1; 33 CFR 320-330, 40 CFR 230	To Be Evaluated	These regulations apply to dredge and fill activities. Under these requirements, no activity that adversely affects a wetland shall be permitted if a practicable alternative that has less adverse effect is available.	During the identification, screening, and evaluation of alternatives, the effects on wetlands are evaluated. If an alternative includes dredge and fill activities, actions must be taken to prevent discharge of dredged or fill materials into the wetlands.
	Wetlands Executive Order (E.O. 11990) & 40 CFR 6, App. A (Policy on Implementing E.O. 11990)	To Be Evaluated	Federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.	Remedial alternatives that involve construction will include all practicable means of minimizing harm to wetlands. Wetlands protection consideration will be incorporated into the planning and decision-making for remedial alternatives. This requirement is applicable to any action that may affect wetland.
	Floodplains Executive Order (E.O. 11988) & 40 CFR 6, App. A (Policy on Implementing E.O. 11988)	To Be Evaluated	Federal agencies are required to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial value of floodplains.	The potential effects of any action must be evaluated to ensure that the planning and decision-making reflect consideration of flood hazards and floodplains management, including restoration and preservation of natural undeveloped floodplains. This requirement is applicable to any action that may affect the floodplain.
	Fish and Wildlife Coordination Act (16 U.S.C. 661)	To Be Evaluated	This regulation requires that any Federal agency that proposes to modify a body of water must consult with the U.S. Fish and Wildlife Service.	During the identification, screening, and evaluation of alternatives, the effects on the wetlands and floodplains are evaluated. If an alternative modifies a body of water, the Navy must consult the U.S. Fish and Wildlife Service.
	RCRA Location Standards (40 CFR 264.18)	To Be Evaluated	This regulation outlines the requirements for construction of a RCRA hazardous waste treatment, storage, or disposal facility within a 100-year floodplain.	A facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood, unless waste may be removed safely before effects on human health and the environment would result if washout occurred. This requirement is applicable if an alternative involves construction of RCRA facility in the 100-year floodplain.

TABLE 9-3
POTENTIAL FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
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AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	National Environmental Policy Act - NEPA (40 CFR Part 6)	To Be Evaluated	The Act requires that a Floodplain/Wetlands Assessment be incorporated into the RI/FS.	Specific remedial alternatives will detail all potential environmental impacts. This requirement is applicable.
	Flood Disaster Protection Act of 1973 and National Flood Insurance Act of 1968 (24 CFR 1909.1-.24)	To Be Evaluated	These Acts contain comprehensive criteria for land management and use in floodplains.	Portions of the site are in a 100-year floodplain. This requirement is applicable to any action that may impact floodplains.
RIVERS				
Federal Regulatory Requirements	Fish and Wildlife Coordination Act (16 U.S.C. 661)	To Be Evaluated	The Act limits activities that may affect fish and wildlife.	If an alternative has the potential to modify the river, the U.S. Fish and Wildlife Service must be consulted. Action must be taken to avoid adverse impacts.
	Wild and Scenic Rivers Act, Protection of Riverways (16 U.S.C. 1271)	To Be Evaluated	Regulates activities in vicinity of designated rivers.	Potential ARARs as site is located in proximity of Hunt's River.
WILDLIFE				
Federal Regulatory Requirements	Endangered Species Act of 1973, Protection of Endangered Species (16 U.S.C. 1531)	To Be Evaluated	Restricts activities in areas inhabited by registered endangered species.	Potential ARAR as surrounding wetlands may sustain endangered or threatened wildlife species.
HISTORIC PLACES				
Federal Regulatory Requirements	National Historic Preservation Act of 1966, Protection of Historic Places (16 USC 470, et seq.)	To Be Evaluated	Requires actions to take into account effects on properties included in or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks.	Potential ARAR for activities which could impact historic places, if encountered.
	Archeological and Historic Preservation Act of 1974, Protection of Archeological and Historic Lands (132 CFR 229 & 229.4., 43 CFR 7 & 7.4)	To Be Evaluated	Restricts the use of land of known archeological or historical significance.	Potential ARAR for activities which could impact archeological or historic places, if encountered.
COASTAL AREAS				
Federal Regulatory Requirements	Coastal Zone Management Act of 1972, Protection of Coastal Areas (16 U.S.C. Sect. 1451)	To Be Evaluated	Regulates land use along coastal areas of the U.S.	Potential ARARs as site is located along Narragansett Bay.

TABLE 9-4
POTENTIAL STATE LOCATION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
WETLANDS				
State Regulatory Requirements	RI Wetlands Law, Regulation of Activities In and Around Wetlands (RIGL, Title 2, Chapter 1)	To Be Evaluated	Provides for classification of coastal wetlands and freshwater wetlands and establishes permit requirements for activities which impact freshwater wetlands.	Potential ARARs if a remedial action is proposed within a wetland area (wetland areas exist adjacent to the site).
COASTAL AREAS				
State Regulatory Requirements	RI Coastal Resources Management Law, Protection of Coastal Areas (RIGL, Title 46, Chapter 23)	To Be Evaluated	Regulates land use in or adjacent to coastal resources.	Potential ARARs as site is located along Narragansett Bay.

TABLE 9-5
POTENTIAL FEDERAL ACTION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
TREATMENT, STORAGE, OR DISPOSAL (General: Groundwater, Soil, Sediment, and Wastes)				
Federal Regulatory Requirements	RCRA Subtitle C (40 CFR parts 261-263)	To Be Evaluated	These regulations specify definitions, hazardous waste classifications and analytical protocols, responsibilities of generators, labeling of drums, storage documentation, and manifest requirements.	Activities performed in connection with the on-site generation and classification of hazardous wastes, and preparation for off-site transport will comply with the requirements of these regulations.
	RCRA Facility Standards (40 CFR 264)	To Be Evaluated	Facility standards specify design, groundwater monitoring, and closure, and post closure care for specific types of facilities.	The selected remedy must conform, to the extent feasible, to the governing technical standards. A groundwater monitoring program must be implemented pursuant to these regulations.
	RCRA - General Facility Standards (40 CFR 264.10 - 264.18	To Be Evaluated	General facility requirements outline general waste analysis, security measures, inspections, and training requirements.	Any facility will be constructed, fenced, posted and operated in accordance with this requirement. All workers will be properly trained. Process wastes will be evaluated for the characteristics of hazardous wastes to assess further handling requirements.
	RCRA - Preparedness and Prevention (40 CFR 264.30 - 264.31)	To Be Evaluated	Outlines requirements for safety equipment and spill control.	Safety and communication equipment will be maintained at the site. Local authorities will be familiarized with the site operations.
	RCRA - Contingency Plan and Emergency Procedures (40 CFR 264.50 - 264.56)	To Be Evaluated	Outlines requirements for emergency procedures to be used following explosions, fires, etc.	Plans will be developed and implemented during site work including installation of monitoring wells and implementation of site remedies. Copies of the plans will be kept on-site.
	RCRA - Manifesting Recordkeeping, and Reporting (40 CFR 264.70 - 264.77)	To Be Evaluated	Specifies the record keeping and reporting requirements for RCRA facilities.	Records of facility activities will be developed and maintained during remedial actions.
	RCRA - Closure and Post-Closure (40 CFR 264.110 - 264.120)	To Be Evaluated	Details specific requirements for closure and post-closure of hazardous waste facilities.	Those parts of the regulation concerned with long-term monitoring and maintenance of the site will be incorporated into the design.

TABLE 9-5
POTENTIAL FEDERAL ACTION-SPECIFIC ARARs AND TBCs
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AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements (Continued)	RCRA Land Disposal Restrictions (LDRs) (40 CFR Part 268)	To Be Evaluated	These regulations identify hazardous wastes that are restricted from land disposal and establish waste analysis and record keeping requirements.	Waste materials generated from the decontamination and/or demolition of building materials and stored on-site need to be analyzed and their disposal will comply with the requirements of these regulations.
SOIL/SEDIMENT/WASTE				
Federal Regulatory Requirements	RCRA - Releases from Solid Waste Management Unit (40 CFR 264.90 - 264.109)	To Be Evaluated	Details requirements for groundwater monitoring and responding to releases from Solid Waste Management Units.	A groundwater monitoring program will be developed in accordance with these requirements for any alternative which involves on-site disposal of soil, sediment, or wastes.
	RCRA - Use and Maintenance of Containers (40 CFR 264 Subpart I, 264.170 - 264.178)	To Be Evaluated	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	Potential ARARs for remedial actions which require storage of hazardous waste in containers.
	RCRA - Surface Impoundments (40 CFR 264.220 - 264.249)	To Be Evaluated	Details the design, construction, operation, monitoring, inspection, and contingency plans for a RCRA surface impoundment. Also provides three closure options for CERCLA sites; clean closure, containment closure, and alternate closure.	Alternatives which include capping or placement of wastes in a new surface impoundment must comply with these regulations.
	RCRA - Waste Piles (40 CFR 264) Subpart L (264.250 - 264.259)	To Be Evaluated	Regulates owners and operators of facilities that store or treat hazardous waste in piles.	Potential ARARs for remedial alternatives which utilize a waste pile for on-site storage/treatment of waste.
	RCRA - On-site Landfill (40 CFR 264.301 - 264.310)	To Be Evaluated	Includes requirements for the design, construction, operation, and maintenance of a RCRA landfill.	Alternatives which involve the disposal of contaminated soils/sediments or wastes in an on-site landfill must meet these requirements.
	RCRA - Land Treatment (40 CFR 264.271 - 264.283)	To Be Evaluated	These regulations detail the requirements for conducting land treatment of RCRA hazardous waste.	Alternatives which involve in-situ or on-site treatment of soil/sediments or wastes must comply with these regulations.
	RCRA - Incineration (40 CFR 264.341 - 264.345)	To Be Evaluated	These regulations detail operating and monitoring requirements and impose performance standards for hazardous waste incinerators.	Alternatives which include incineration of contaminated soil/sediment or wastes must comply with these requirements and meet the mandated performance standards.
	Land Disposal Restrictions (40 CFR 268)	To Be Evaluated	This regulation establishes "treatment standards" (concentration levels or methods of treatment) which wastes must meet in order to be eligible for land disposal.	Contaminated soil/sediment or wastes must be treated to attain applicable "treatment standards" prior to placement in a landfill, or other land disposal facility.

TABLE 9-5
POTENTIAL FEDERAL ACTION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
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AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	CWA Dredge and Fill Regulations (40 CFR 230; 33 CFR 320-330)	To Be Evaluated	These regulations outline requirements for dredging and discharge of dredged or fill material. Under this requirement, no activity that impacts a wetland shall be permitted if a practicable alternative exits; all impacts must be mitigated.	Alternatives involving the dredging of contaminated sediments from wetland areas must comply with these requirements. Controls must be used to minimize adverse impacts.
	Miscellaneous Treatment Units (40 CFR 264.601)	To Be Evaluated	This regulation details design and operating standards for units in which hazardous waste is treated.	Hazardous waste treatment units used for on-site treatment of contaminated media must meet these requirements.
	Protection of Archeological Resources (32 CFR Part 229, 229.4; 43 CFR Parts 107, 171.1-171.5)	To Be Evaluated	This regulation develops procedures for the protection of archeological resources.	If archeological resources are encountered during soil excavation, they must be reviewed by Federal and State archaeologists. This requirement is applicable to any excavation onsite.
GROUNDWATER				
Federal Regulatory Requirements	CWA - National Pollutant Discharge Elimination System (NPDES) (40 CFR 122, 125)	To Be Evaluated	Any point-source discharge must meet NPDES requirements which include compliance with corresponding water quality standards; establishment of a discharge monitoring system; and completions of regular discharge monitoring records.	Groundwater and process water treated on-site and discharged to the Quinnipiac River will need to comply with the water quality standards established by the state under these regulations.
	CWA Pre-treatment Regulations (40 CFR 403)	To Be Evaluated	These regulations impose restrictions on the discharge of pollutants to Publicly Owned Treatment Works (POTW) and mandate that discharges must comply with the local pretreatment program.	Groundwater and process water treated on-site and discharged to a POTW must comply with these regulations.
	Underground Injection Control Regulations (40 CFR Parts 144, 145, 146, and 147)	To Be Evaluated	These regulations provide regulatory compliance standards for treatment facilities that inject wastes underground.	Remedial alternatives that include groundwater recirculation systems must comply with these regulations.
AIR				
Federal Regulatory Requirements	RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	To Be Evaluated	Regulates facilities that have operations involving air emissions above specified levels, where appropriate.	Alternatives which result in air emissions, must conform to these requirements.
	RCRA 40 CFR Subpart BB, Air Emission Standards for Equipment Leaks	To Be Evaluated	Requirements governing response to equipment leaks at facilities that may cause air emissions.	If during implementation of selected remedy, equipment leaks occur the response must be in conformance with this regulation.

TABLE 9-5
POTENTIAL FEDERAL ACTION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
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AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	CAA NAAQS for Total Suspended Particulates (40 CFR 129.105, 40 CFR 750)	To Be Evaluated	This regulation specifies maximum primary and secondary 24-hour concentrations for particulate matter.	Fugitive dust emissions from site excavation activities will be maintained below 260 ug/m^3 (primary standard) by dust suppressants, if necessary. If any excavation occurs, this requirement will be applicable.
Criteria, Advisories, Guidance	OSWER Directive 9355.0-28, Air Stripper Control Guidance	To Be Evaluated	Guidance regarding use of air emission controls at CERCLA sites.	This guidance will be considered during the development, evaluation, and selection of alternatives.
PCBs				
Federal Regulatory Requirements	Toxic Substance Control Act (TSCA), Storage and Disposal Requirements for PCB - contaminated Materials (40 CFR 761, Subpart D)	To Be Evaluated	Establishes treatment and disposal requirements for PCB - contaminated materials.	Potential ARARs for alternatives which involve treatment or disposal of PCB - contaminated materials, including soils.
TRANSPORTATION				
Federal Regulatory Requirements	Hazardous Materials Transportation Act, Rules of Transportation of Hazardous Materials (49 CFR 170, 171)	To Be Evaluated	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	ARARs for alternatives involving the off-site shipment of hazardous materials or waste.
HEALTH AND SAFETY				
Federal Regulatory Requirements	Occupational Safety and Health Act, Recordkeeping, Reporting and Related Regulations (29 CFR 1904)	To Be Evaluated	Outlines recordkeeping and reporting requirements.	ARARs for all contractors/subcontractors involved in hazardous activities.
	OSHA, General Industry Standards (29 CFR 1910)	To Be Evaluated	Establishes requirements for 40-hour training and medical surveillance of hazardous waste workers. Establishes Permissible Exposure Limits (PELs) for workers at hazardous waste operations and during emergency response.	ARARs for workers and the workplace throughout the implementation of hazardous activities.
	OSHA, Safety and Health Standards (29 CFR 1926)	To Be Evaluated	Regulation specify the type of safety equipment and procedures for site remediation/excavation.	ARARs for workers and the workplace throughout the implementation of hazardous activities.

TABLE 9-6
POTENTIAL STATE ACTION-SPECIFIC ARARs AND TBCs
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
State Regulatory Requirements	RI Water Pollution Control Act, RI Water Quality Regulations (RIGL, Title 46, Chapter 12)	To Be Evaluated	Requirements for discharging to area waters.	Potential ARARs for alternatives which involve the discharge of treated water to surface water or ground water.
	RI Water Pollution Control Act, RI Water Quality Regulations (RIGL, Title 46, Chapter 12)	To Be Evaluated	Permits and regulates discharge to area surface waters.	Potential ARARs for alternatives which involve the discharge of treated water to surface water.
	RI Water Pollution Control Act, RI Water Quality Regulations (RIGL, Title 46, Chapter 12)	To Be Evaluated	Rules concerning pretreatment of water prior to discharge to a POTW.	Potential ARARs for alternatives involving the use of Publicly Owned Treatment Works (POTW).
	RI Water Pollution Control Act, RI Water Quality Regulations (RIGL, Title 46, Chapter 12)	To Be Evaluated	Rules concerning the reinjection of treated ground water.	Potential ARARs for alternatives involving the reinjection of treated ground water.
	Public Drinking Water Laws, Protection of Public Drinking Water (RIGL, Title 46, Chapter 14)	To Be Evaluated	Establishes rules concerning discharge to any source of water supply for drinking purposes.	Potential ARARs for alternatives which affect public public drinking water supplies.
	RI Groundwater Protection Act, Protection of Ground Water (RIGL, Title 46, Chapter 13.1)	To Be Evaluated	Establishes ground water classifications and maximum contaminant levels for each classification.	Potential ARARs for alternatives involving the treatment of contaminated ground water. Will establish cleanup levels.
	RI Hazardous Waste Management Act of 1978, Hazardous Waste Management (RIGL, Title 23, Chapter 19.1)	To Be Evaluated	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal.	ARARs for alternatives involving the hazardous waste management or on-site or off-site disposal activities.
	RI Refuse Disposal Law, Solid Waste Management	To Be Evaluated	Rules and regulations for solid waste management facilities.	ARARs for alternatives involving the on-site storage and disposal of solid wastes.
	RI Underground Storage Tanks Act, Regulations for Underground Storage Facilities used for petroleum Products and Hazardous Materials (RIGL, Title 46, Chapter 12.1)	To Be Evaluated	Permits and regulates installation, operation, and closure of underground storage tanks.	ARARs for alternatives involving closure of existing underground storage tanks.
	RI Clean Air Act, General Air Quality and Air Emissions Requirements (RIGL, Title 23, Chapter 23)	To Be Evaluated	Set emissions limitations for particulates and visible air contaminants.	ARARs for alternatives involving remedial actions which impact ambient air.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4)	To Be Evaluated	Establishes rules for the public's right-to-know concerning hazardous waste storage and transportation.	ARARs for alternatives involving handling of hazardous waste materials and transportation off-site.

TABLE 9-7
SUMMARY OF PRELIMINARY REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

Environmental Media	Preliminary Remedial Action Objectives (from site characterization)	General Response Action (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Soil/Sediment	Protection of Human Health:	• No Action	• No Action	• No Action
	Prevent the ingestion of and dermal contact with soil having carcinogenic contaminants posing a total excess cancer risk of 10^{-4} to 10^{-6}.	• Limited Action	• Limited Action Technologies: - Access restrictions - Institutional Controls - Long-term monitoring	- Fencing - Deed restrictions, land-use zoning - Groundwater monitoring
	Prevent the ingestion and dermal contact with soil having non-carcinogenic contaminants with a Hazard Quotient greater than 1.0 for each contaminant.	• Containment Actions:	• Containment Technologies: - Horizontal barriers - Vertical barriers	- Clay cap, synthetic membrane, multi-layer membranes - Slurry walls, sheet piling - Grout injection - Pumping wells, trenches or french drains
	Prevent contaminant migration from soils that would result in groundwater contamination in excess of MCLs and non-zero MCLGs.	• Removal and Disposal (untreated, contaminated soils)	• Removal Technologies: - Excavation - Discrete removal • Disposal Technologies: - Landfill - Land disposal	- Bulk solids excavation, clam-Shell dredge - Discrete removal - Off-site landfill, on-site landfill - Consolidation

TABLE 9-7
SUMMARY OF PRELIMINARY REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
PAGE TWO

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Action (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Soil/Sediment (continued)	For Environmental Protection: Prevent contact by ecological receptors with soils having contaminant concentrations in excess of bench toxicity values for organics or background concentrations for metals	• Excavation, Treatment, and Disposal	• Excavation Technologies: - Excavation - Discrete removal • Ex-situ Treatment Technologies: - Thermal Treatment - Physical/Chemical treatment - Immobilization - Biological treatment • Disposal Technologies - Landfill - Land disposal	- Bulk solids excavation, clam shell dredge - Discrete removal - Incineration, pyrolysis, low temperature thermal - Soil washing, solvent extraction, dechlorination - Fixation, sorption, micro-encapsulation, clay pelletizing/sintering - Aerobic biodegradation, anaerobic biodegradation - Off-site landfill, on-site landfill - Beneficial re-use, consolidation
		• In-Situ Treatment	• In-situ Treatment Technologies: - Thermal treatment - Physical/chemical treatment - Immobilization - Biological treatment	- In-situ vitrification - Soil vapor extraction, soil flushing - In-situ fixation - In-situ biodegradation

TABLE 9-7
SUMMARY OF PRELIMINARY REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
PAGE THREE

Environmental Media	Preliminary Remedial Action Objectives (from site characterization)	General Response Action (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Groundwater and Surface Water	Protection of Human Health:	• No Action	• No Action	• Not Applicable
	Prevent ingestion of groundwater having carcinogenic contaminants in excess of MCLs and having a total excess cancer risk (sum of all contaminants) greater than 10^{-4} to 10^{-6}.	• Limited Action	• Limited Action Technologies: - Institutional Controls - Long-term monitoring	- Deed restrictions - Groundwater monitoring
	Prevent ingestion of groundwater having non-carcinogenic contaminants in excess of MCLs or having a Hazard Quotient greater than 1.0 for each contaminant.	• Collection and Discharge (clean groundwater only)	• Collection/Diversion Technologies: - Extraction - Enhanced removal	- Extraction wells, Collection trench, - Blasting/hydrofracturing
			• Discharge Technologies: - Beneficial re-use - Surface discharge - Subsurface discharge	- On-site use, Off-site use - Direct surface discharge, Indirect surface discharge (POTW) - Underground injection

TABLE 9-7
SUMMARY OF PRELIMINARY REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL
PAGE FOUR

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Action (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Groundwater	Protection of the Environment: Prevent continuing migration of contaminant in the groundwater and protect uncontaminated groundwater. Prevent continuing migration of contaminants to surface water.	• Collection, Treatment, and Discharge	• Collection Technologies: - Extraction - Enhanced removal • Treatment Technologies - Physical - Chemical - Biological • Discharge Technologies: - Beneficial re-use - Surface discharge - Subsurface discharge	- Extraction wells, Collection trench - Blasting/hydrofracturing - Equalization, dewatering, sedimentation, oil-water separation, filtration, reverse osmosis, air stripping, carbon adsorption, extraction, distillation, evaporation, electrodialysis, detonation - Ion exchange, electrolytic recovery, enhanced oxidation, chemical oxidation, reduction, neutralization, precipitation, coagulation-flocculation, dechlorination - Aerobic biodegradation, anaerobic biodegradation - On-site use, off-site use - Direct surface discharge, indirect surface discharge (POTW), off-site treatment facility - Underground injection

TABLE 9-8
PRELIMINARY SOIL/SEDIMENT REMEDIAL ALTERNATIVES
PHASE II RI/FS
SITE 02 - MELVILLE NORTH LANDFILL

RESPONSE ACTION	REMEDIAL ALTERNATIVE/TECHNOLOGY	DATA REQUIREMENTS
NO ACTION	Access Restrictions Fence/Warning Signs	Risk assessment Administrative requirements
INSTITUTIONAL CONTROL	Deed Restrictions	Risk assessment Administrative requirements
CONTAINMENT	Capping Vertical Barrier	Risk assessment, permeability Hydrogeologic data
TREATMENT*	On-site Treatment	Treatability Studies/Pilot Testing
	Volatiles: Thermal Treatment Plasma Arc Pyrolysis	 Ash content, moisture content Moisture content, ash, inorganics
	Semivolatiles: Dechlorination Soil Washing Thermal Immobilization	 Particle size distribution, chem. analyses Particle size distribution Ash content, moisture content
	Inorganics: Soil Stabilization Soil Washing Thermal Immobilization	 Moisture content Particle size distribution Moisture content
	In Situ Treatment: Biodegradation (organics) Stabilization Soil Venting (organics) Vitrification	Treatability Studies/Pilot Studies BOD/COD, TOC, pH Moisture content Particle size distribution, air permeability Contaminant depth, geology, hydrogeology data
	Off-site Treatment: Incineration Various others	 Incinerator availability Waste analysis

* A risk assessment and contaminant leaching modeling may also be data requirements for establishing levels of treatment.

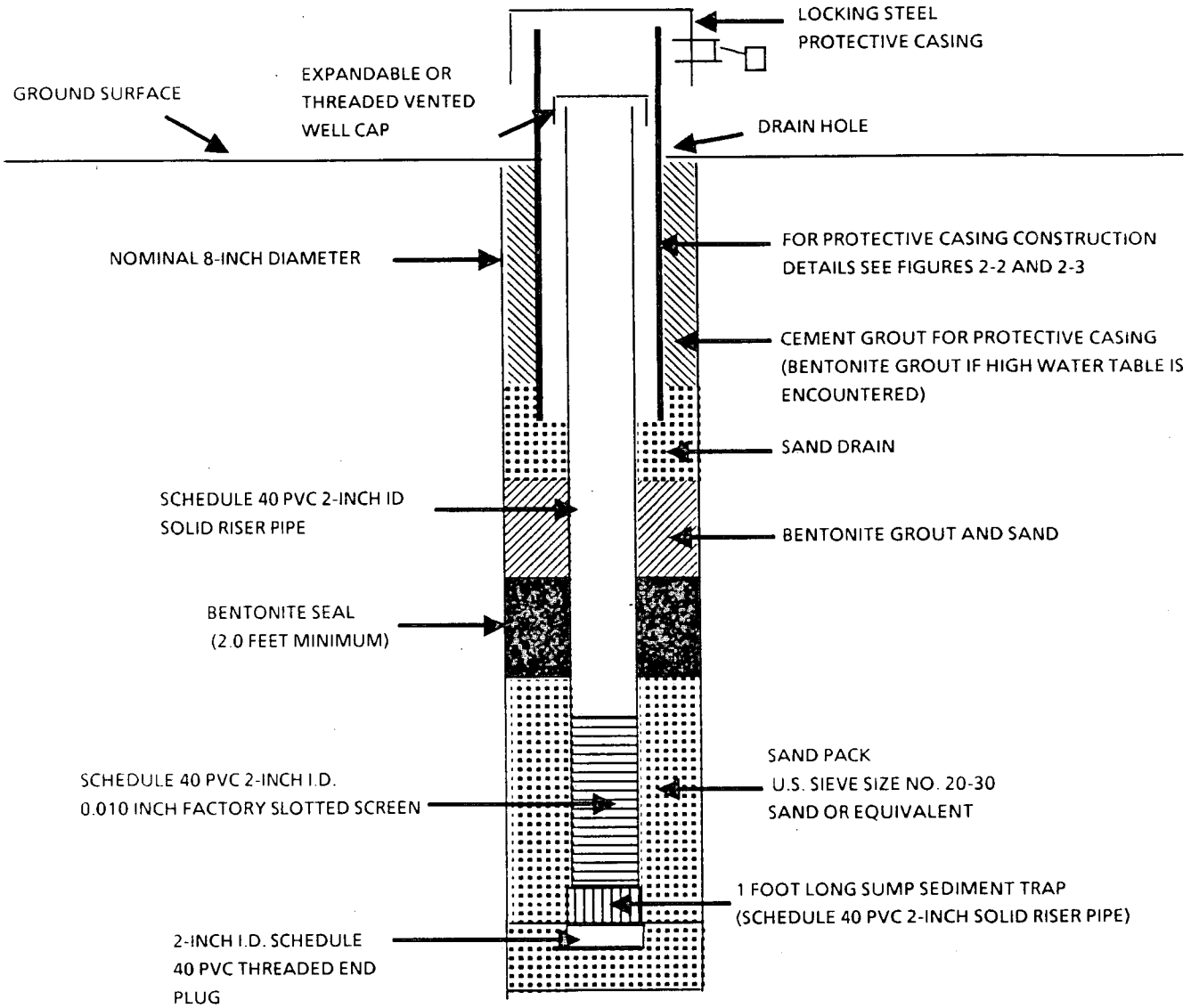
TABLE 9-9
PRELIMINARY GROUNDWATER REMEDIAL ALTERNATIVES
PHASE II RI/FS
SITE 02 - MELVILLE NORTH LANDFILL

RESPONSE ACTION	REMEDIAL ALTERNATIVE/TECHNOLOGY	DATA REQUIREMENTS
NO ACTION	Fence/Warning Signs Continued Monitoring	Risk assessment Risk assessment Administrative requirements
INSTITUTIONAL CONTROL	Groundwater Use Restrictions	Risk assessment Administrative requirements
CONTAINMENT	Capping Vertical Barrier	Risk assessment, permeability Hydrogeologic data
EXTRACTION/COLLECTION	Extraction Wells Well Points French Drains Diversion Structures	Hydrogeologic data Hydrogeologic data Hydrogeologic data Hydrologic data
ON-SITE TREATMENT*	Organics: Biodegradation PACT™ Air Stripping Steam Stripping Carbon Adsorption Resin Adsorption UV Oxidation	Treatability Studies/Pilot Testing Chemical analyses BOD/COD Henry's Law constants Henry's Law constants Adsorption isotherms Suspended solids pH, temperature, TDS
	Inorganics: Reverse Osmosis Ion Exchange Precipitation Membrane Microfiltration Electrochemical	Chemical analyses pH, suspended solids Suspended solids TDS, suspended solids Suspended solids pH
	Biodegradation	Chemical analyses BOD/COD, pH
	Injection Wells Infiltration Galleries Surface Water POTW RCRA Facility	Hydrogeologic data Hydrogeologic data Regulatory requirements Administrative/technical requirements Location/capacity/unit processes

* A risk assessment and water quality criteria may also be data requirements for establishing levels of treatment.

FIGURES

OVERBURDEN WELL

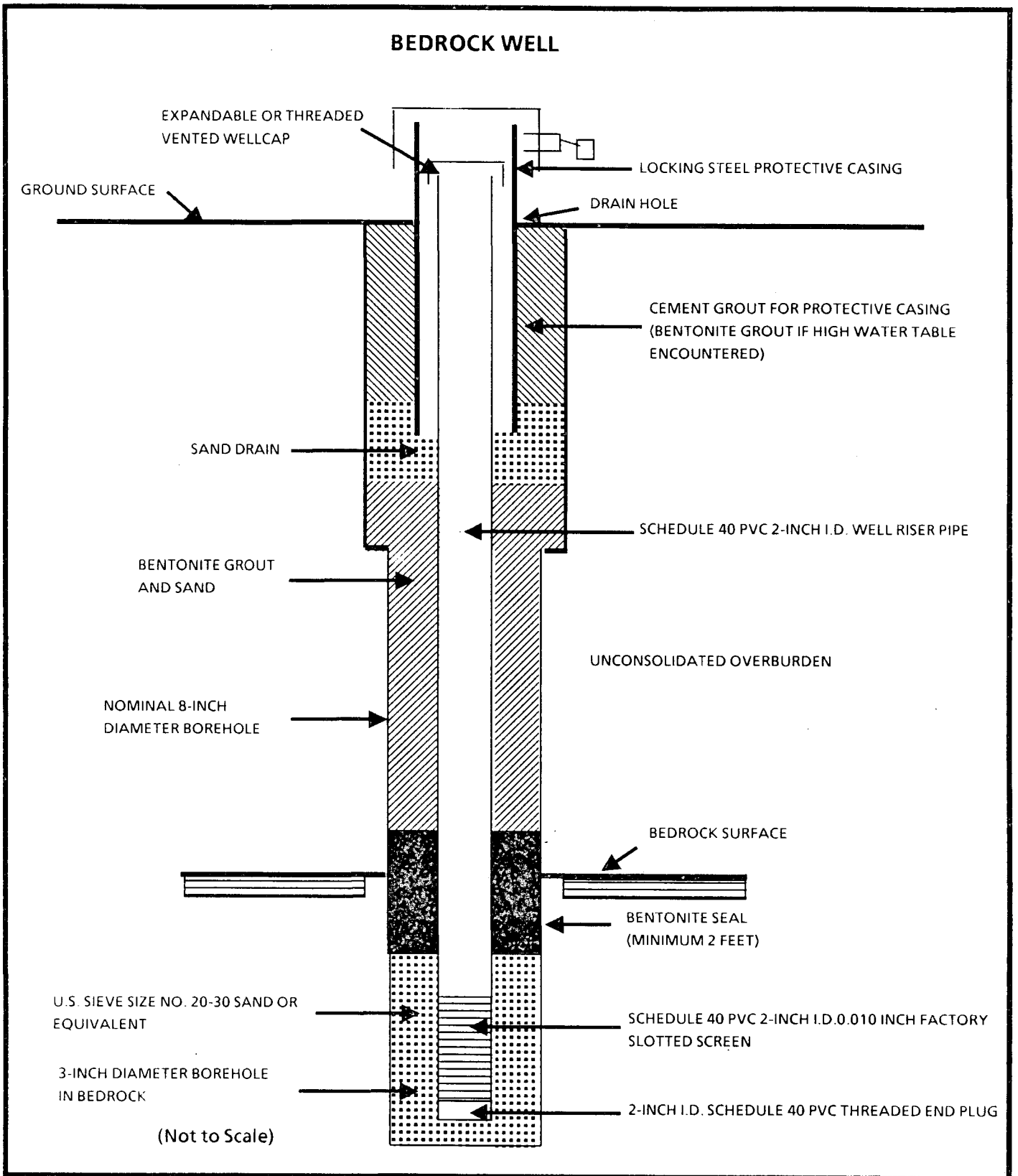


(Not to Scale)

PROPOSED OVERBURDEN MONITORING WELL CONSTRUCTION DETAILS
MELVILLE NORTH LANDFILL
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Halliburton NUS CORPORATION

FIGURE 4-7



PROPOSED BEDROCK MONITORING WELL CONSTRUCTION DETAILS
MELVILLE NORTH LANDFILL
NAVAL EDUCATION TRAINING CENTER
NEWPORT, RHODE ISLAND

Halliburton NUS CORPORATION

FIGURE 4-8

FIGURE 5-1
PROJECT ORGANIZATION
CTO 172
MELVILLE NORTH LANDFILL
NETC NEWPORT, RHODE ISLAND

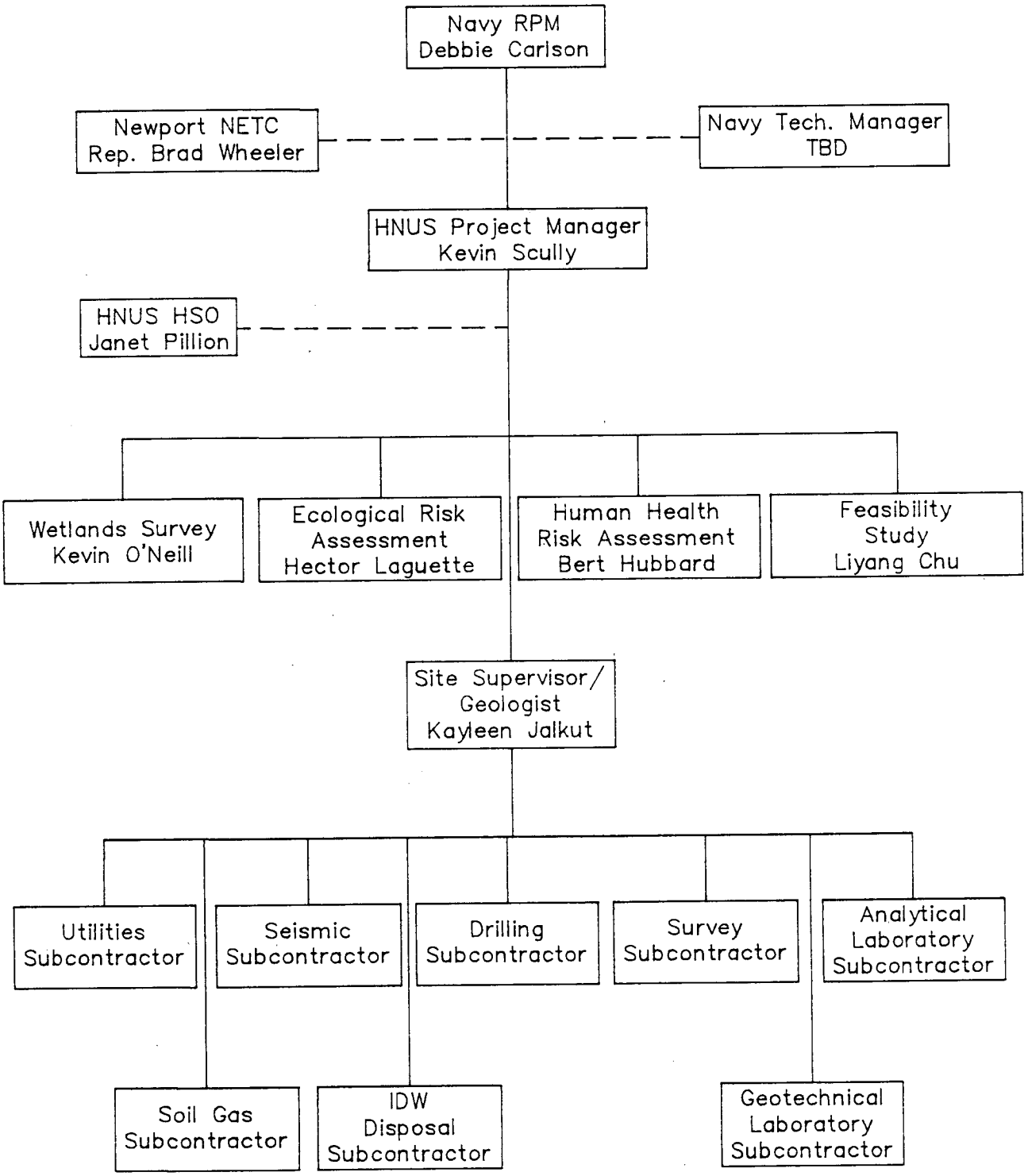
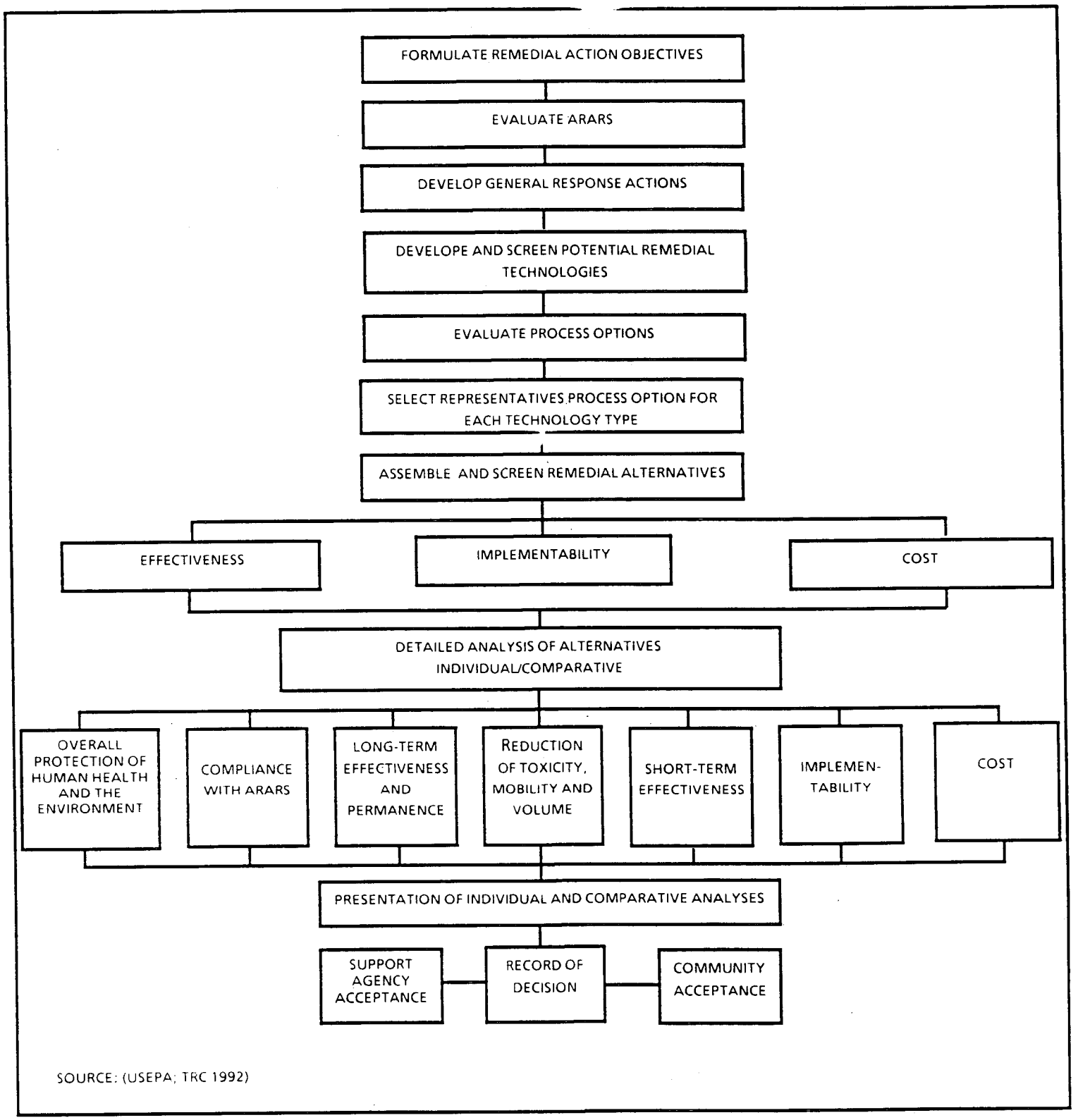
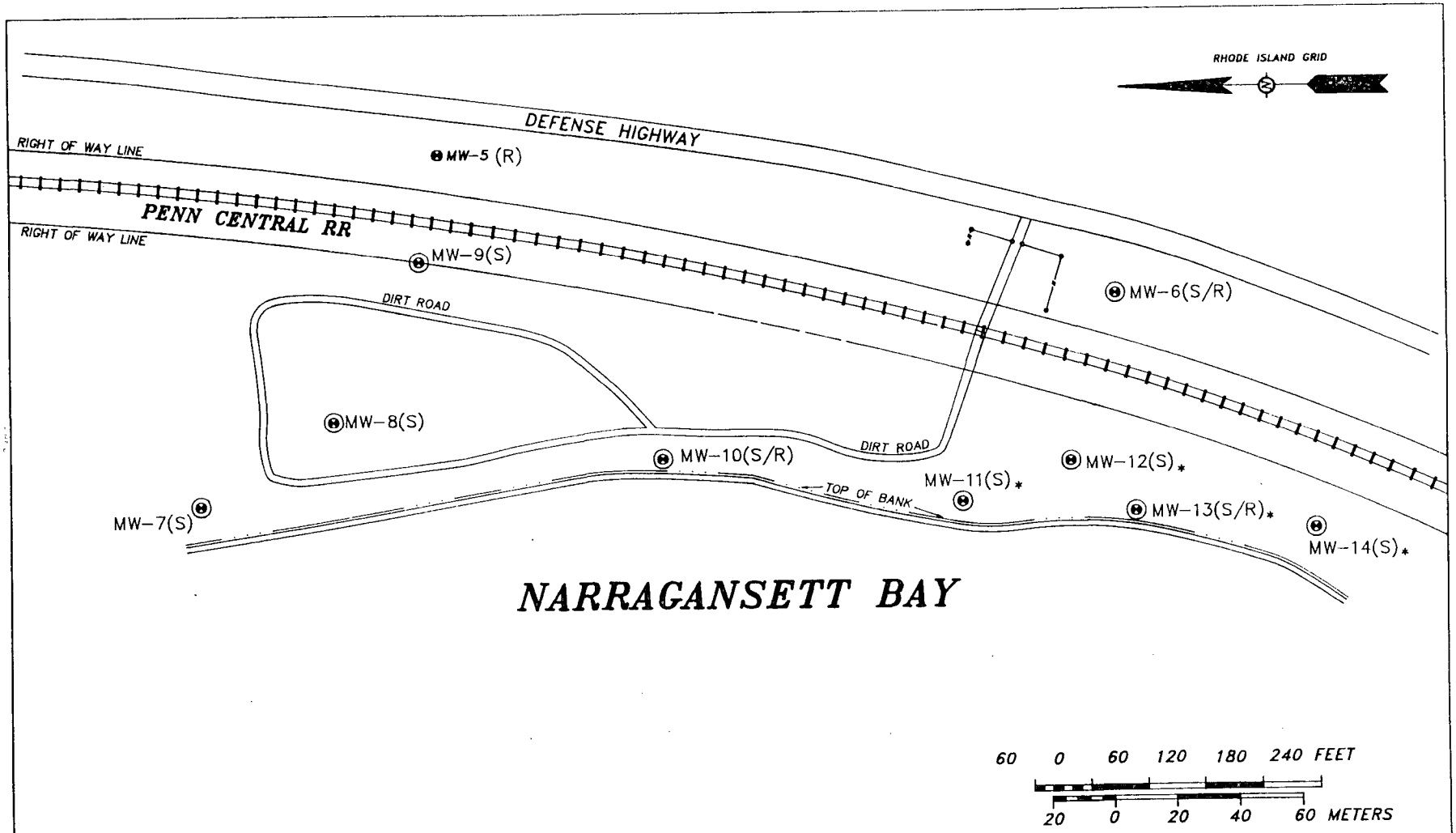


FIGURE 10-1
FEASIBILITY STUDY PROCESS



SOURCE: (USEPA; TRC 1992)



LEGEND

MW-7	PROPOSED MONITORING WELL LOCATION
(S)	PROPOSED NEW SHALLOW WELL
(R)	PROPOSED NEW BEDROCK WELL
*	LOCATIONS BASED UPON SOIL GAS FINDINGS

Halliburton NUS CORPORATION

187 BALLARDVALE STREET
SUITE A-100
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

PROPOSED MONITORING WELL LOCATIONS
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
SCALE: 1" = 180'	DATE: AUGUST 1994	W.A. NO: CTO 172
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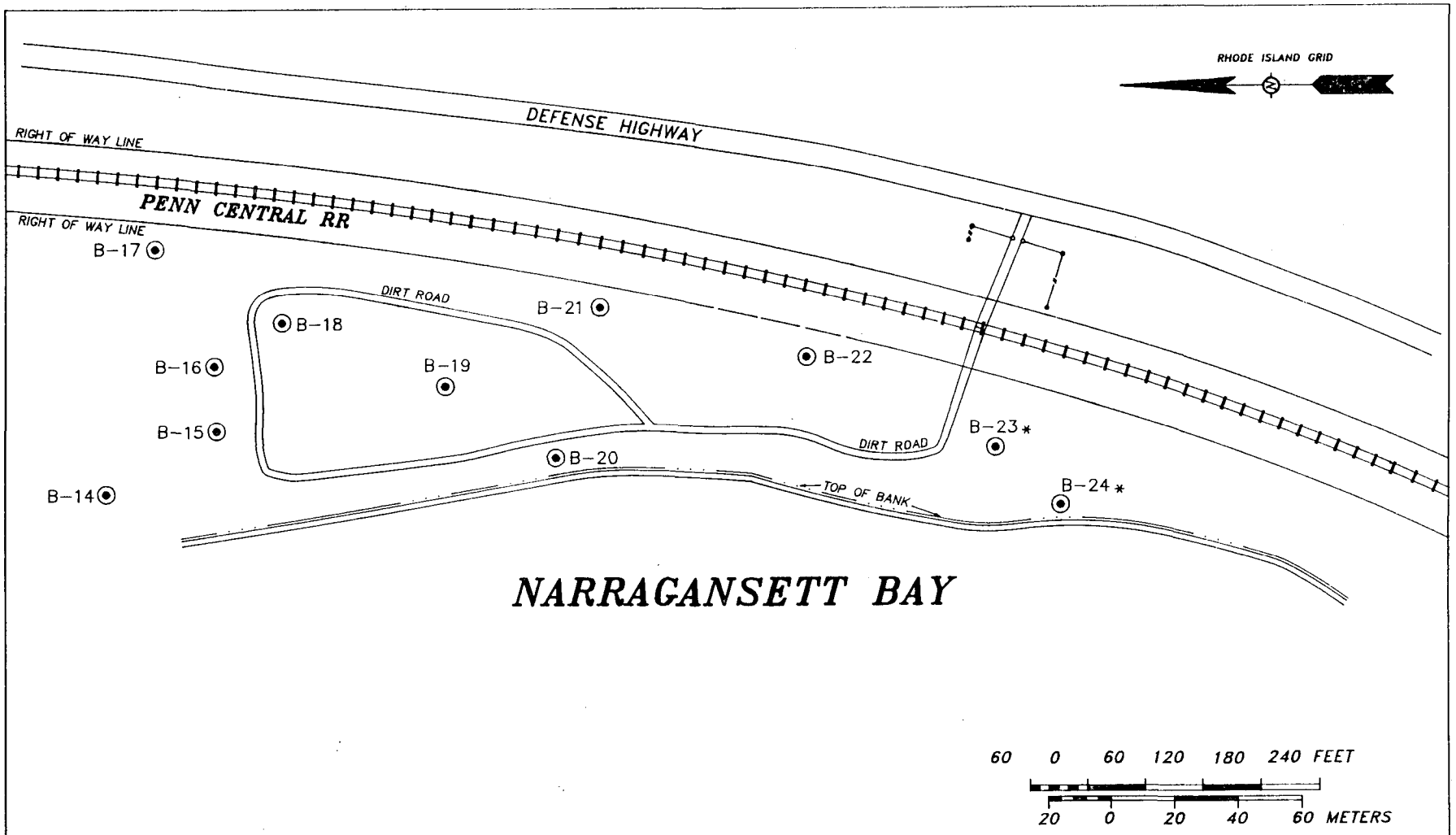

LEGEND

B-14 ⊙ PROPOSED SOIL BORING LOCATION

* LOCATIONS BASED UPON SOIL GAS FINDINGS

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PROPOSED SOIL BORING LOCATIONS
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

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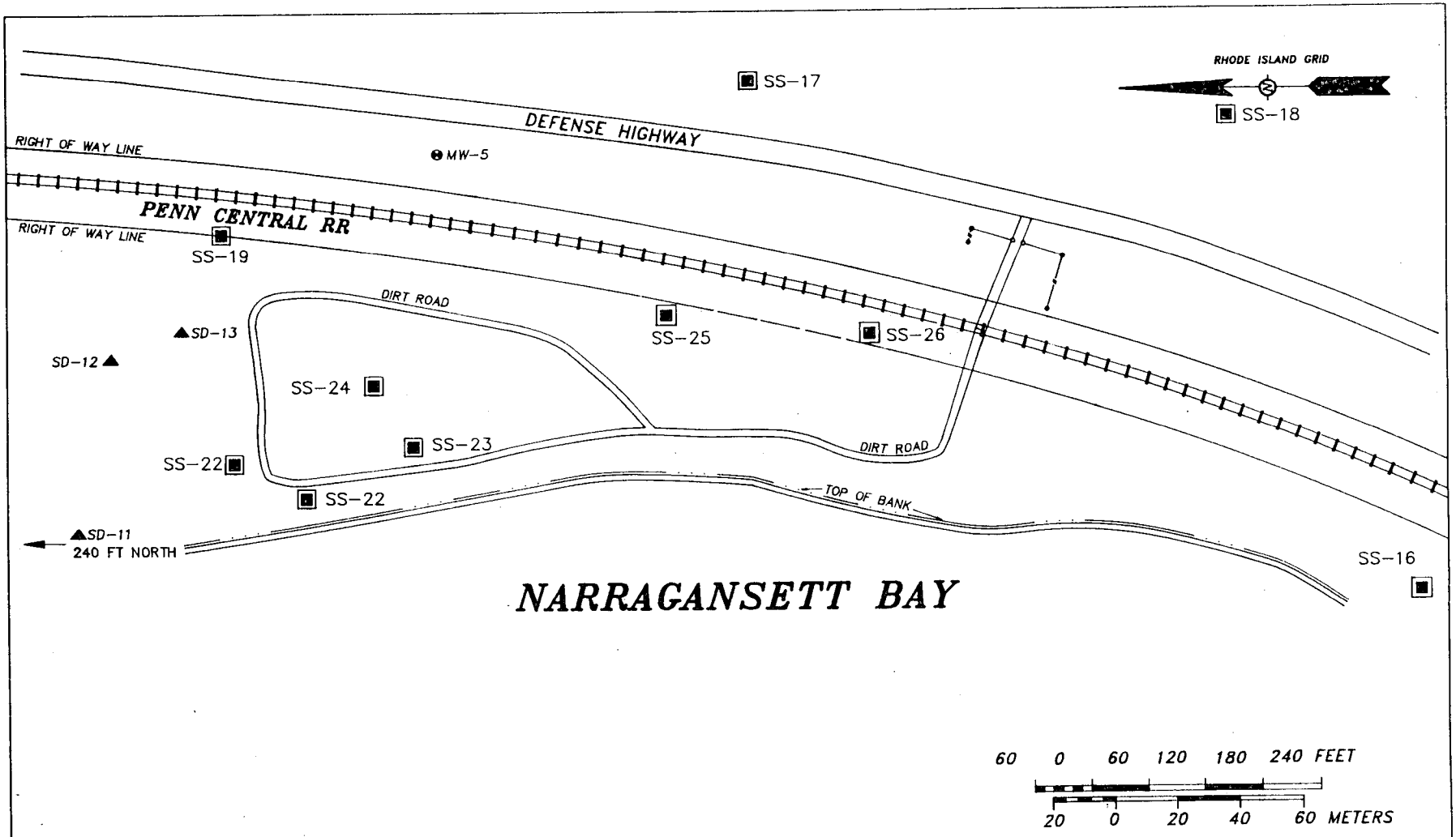

LEGEND

SS-22 PROPOSED SURFACE SOIL LOCATION

SD-11 PROPOSED SEDIMENT SAMPLE LOCATION

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PROPOSED SURFACE SOIL & SEDIMENT SAMPLE LOCATIONS
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
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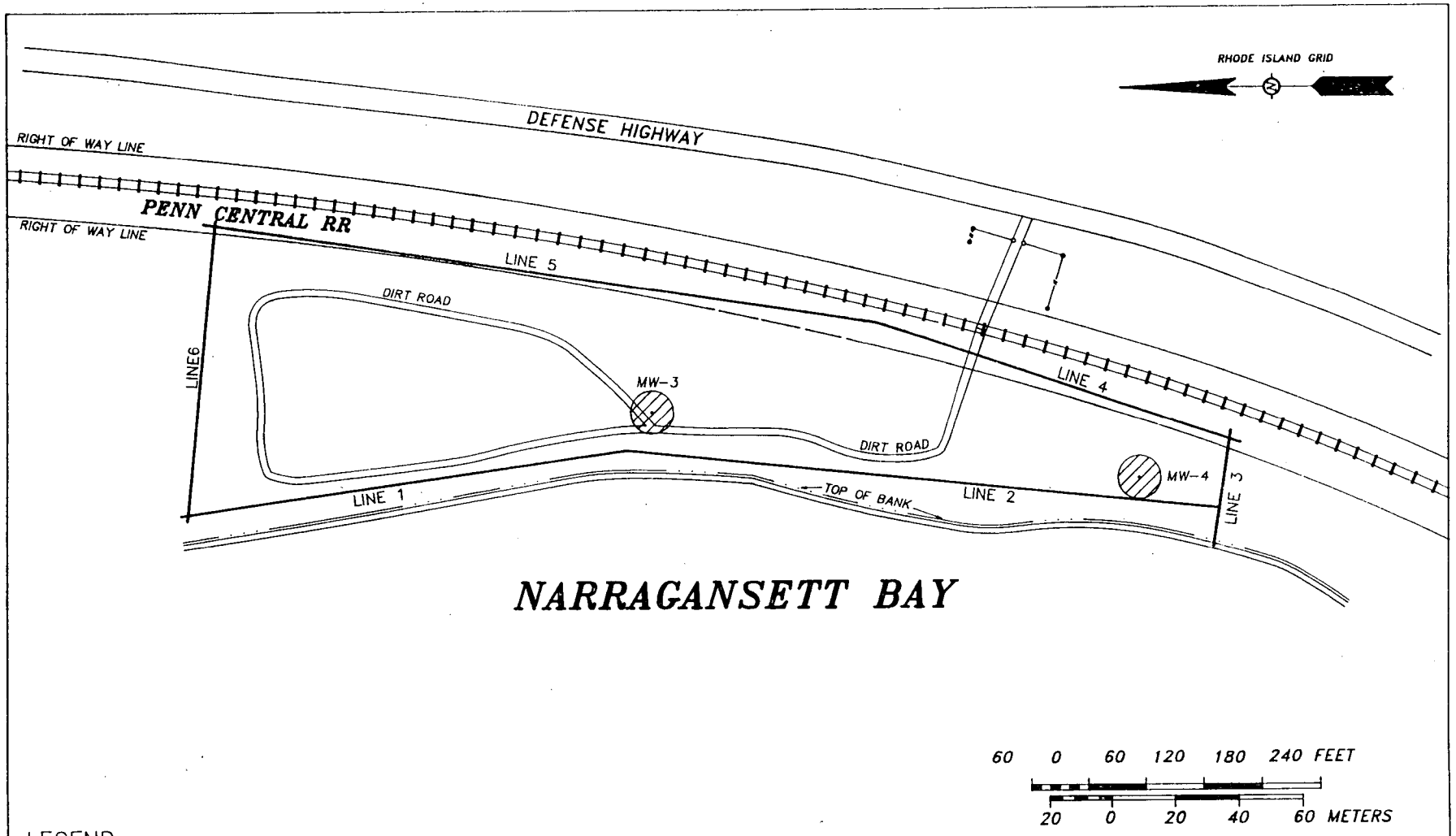

LEGEND

FENCE

PROPOSED SOIL GAS SURVEY AREAS (25' RADIUS)

PROPOSED SEISMIC REFRACTION LINE

* PROPOSED COVERAGE. ACTUAL COVERAGE TO BE DETERMINED BY SEISMIC CONTRACTOR BASED ON SITE CONDITIONS AND DATA REVIEWS

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PROPOSED SOIL GAS SURVEY AREAS & SEISMIC REFRACTION SURVEY LINES
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
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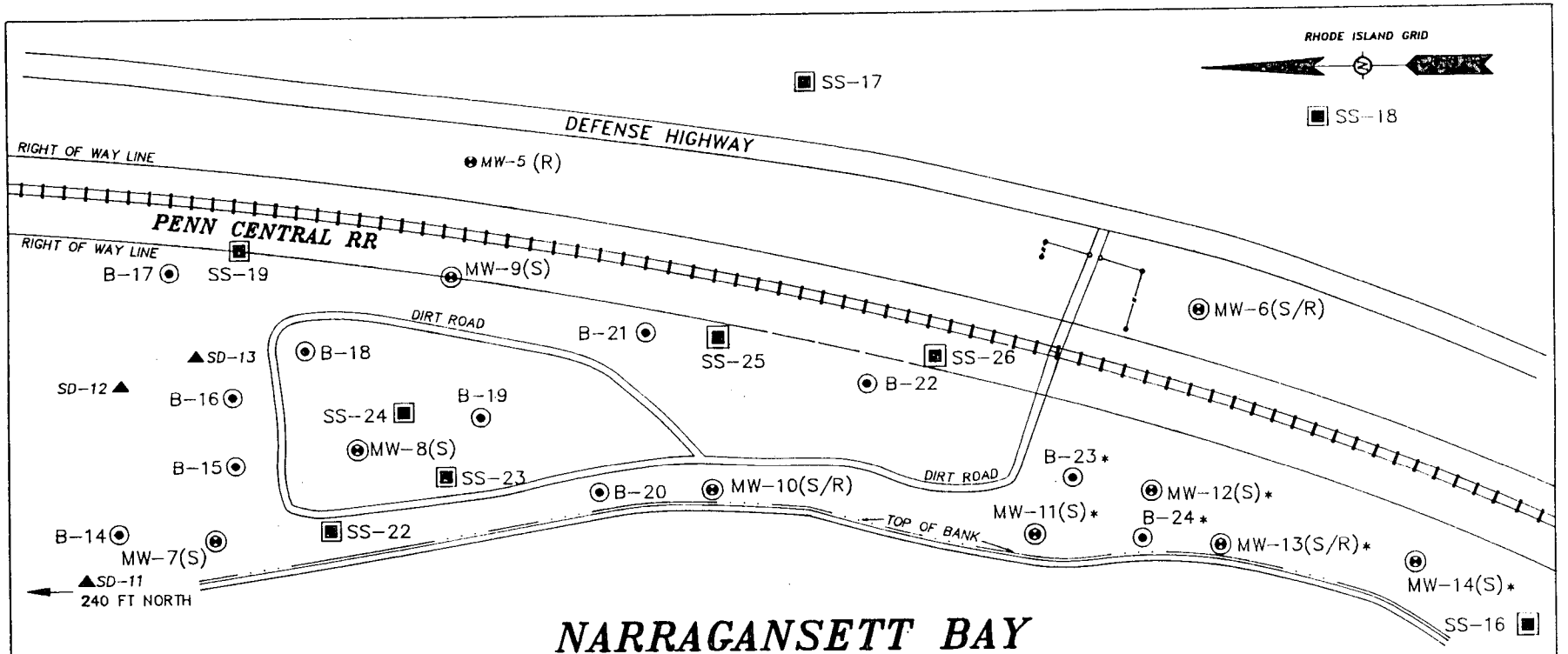

LEGEND

SS-22 ■	PROPOSED SURFACE SOIL SAMPLE LOCATION
SD-12 ▲	PROPOSED SEDIMENT SAMPLE LOCATION
MW-11 ⊗	PROPOSED MONITORING WELL LOCATION
B-20 ⊙	PROPOSED BORING LOCATION
(S)	PROPOSED NEW SHALLOW WELL
(R)	PROPOSED NEW BEDROCK WELL
*	LOCATIONS BASED UPON SOIL GAS FINDINGS

60 0 60 120 180 240 FEET

20 0 20 40 60 METERS

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PROPOSED PHASE II INVESTIGATION SUMMARY MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
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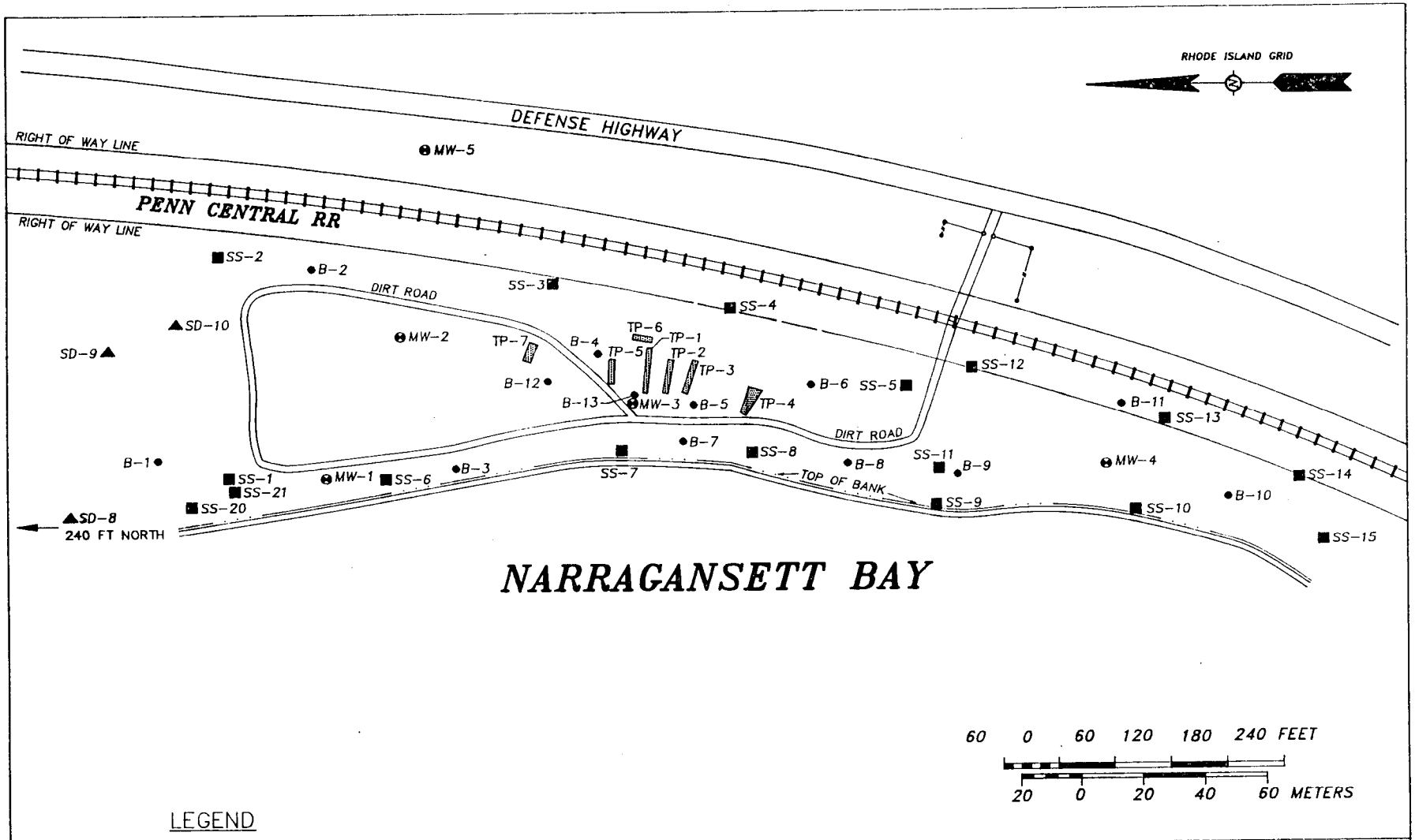

LEGEND

SS-8 ■ SURFACE SOIL SAMPLE LOCATION

B-7 ● BORING LOCATION

MW-4 ⊖ MONITORING WELL LOCATION

SD-10 ▲ SEDIMENT SAMPLE LOCATION

TP-7 ▨ TEST PIT LOCATION

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WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

PHASE I INVESTIGATION SUMMARY MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
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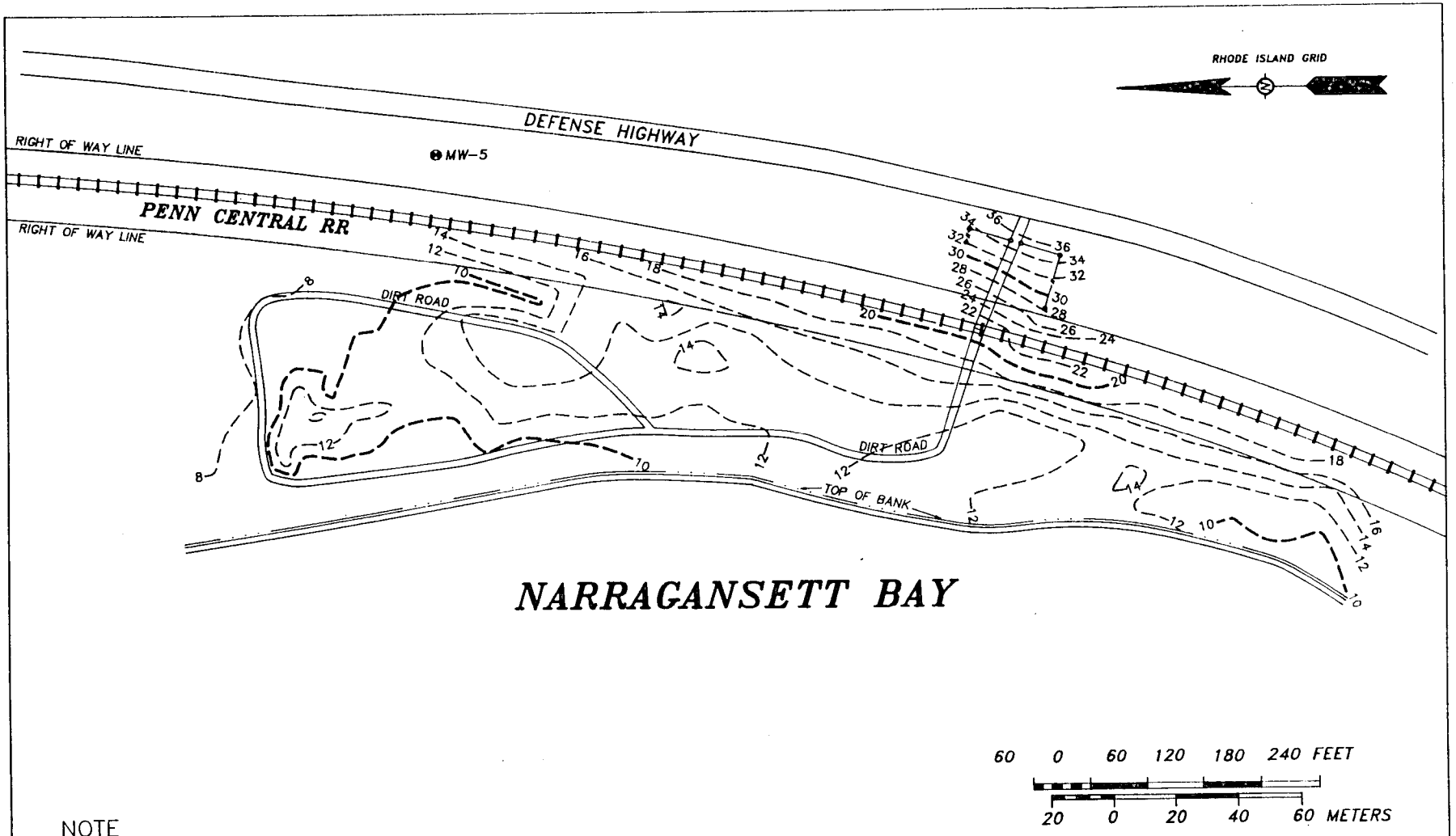

NOTE

SITE TOPOGRAPHIC SURVEY CONDUCTED IN 1991 AND DOES NOT REFLECT ELEVATION CHANGES CREATED BY 1994 SURFACE SOIL EXCAVATION ACTIVITY.

LEGEND

---10--- CONTOUR LINE (10 FOOT INTERVAL)

--12-- CONTOUR LINE (2 FOOT INTERVAL)

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(508)658-7899

SITE TOPOGRAPHIC SURVEY MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
SCALE: 1" = 180'	DATE: AUGUST 1994	W.A. NO: CTO 172
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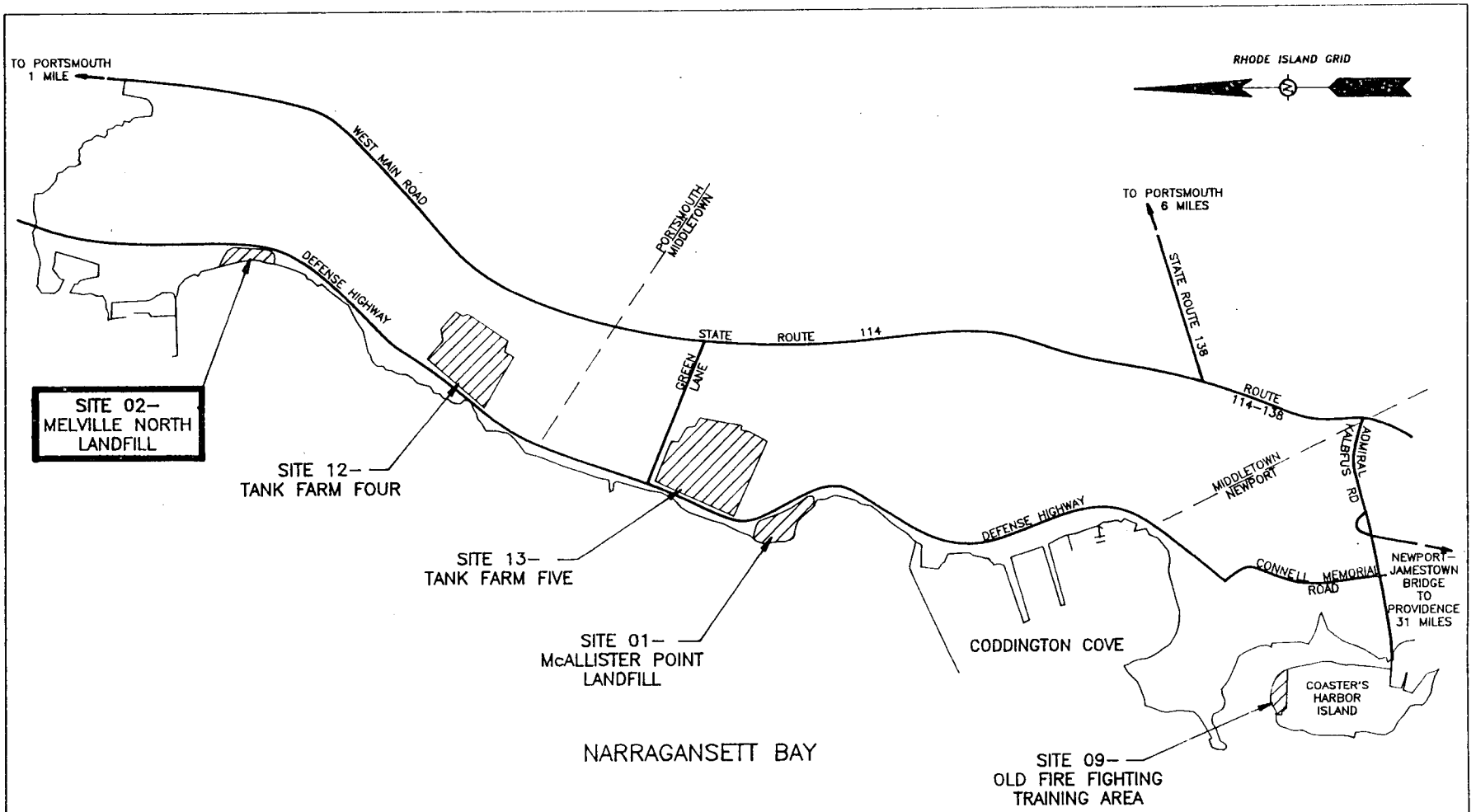

SCALE

0 4000 8000 FEET

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SUITE A-100
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

NETC SITE LOCATION MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
SCALE: 1" = 4000'	DATE: AUGUST 1994	W.A. NO: CTO 172
DRAWING NO: FIGURE 2-1	ACFILE NAME: C:\MELVILL\MEL1.DWG	REV:

APPENDIX A

HEALTH AND SAFETY PLAN

W5294051F

APPENDIX A
HEALTH AND SAFETY PLAN
FOR
PHASE II RI/FS WORK PLAN
SITE 02 - MELVILLE NORTH LANDFILL

NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Submitted to:
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 172

October 1994

KEVIN J. SCULLY
PROJECT MANAGER
HALLIBURTON NUS CORPORATION
WILMINGTON, MASSACHUSETTS

for
MATTHEW SOLTIS, CSP, CIH
CLEAN HEALTH & SAFETY MANAGER
HALLIBURTON NUS CORPORATION
PITTSBURGH, PENNSYLVANIA

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ATTACHMENT A - HEAT AND COLD STRESS

ATTACHMENT B - MSDS' AND HEALTH HAZARD INFORMATION

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8-3	Newport Hospital Route Map	8-5

1.0 INTRODUCTION

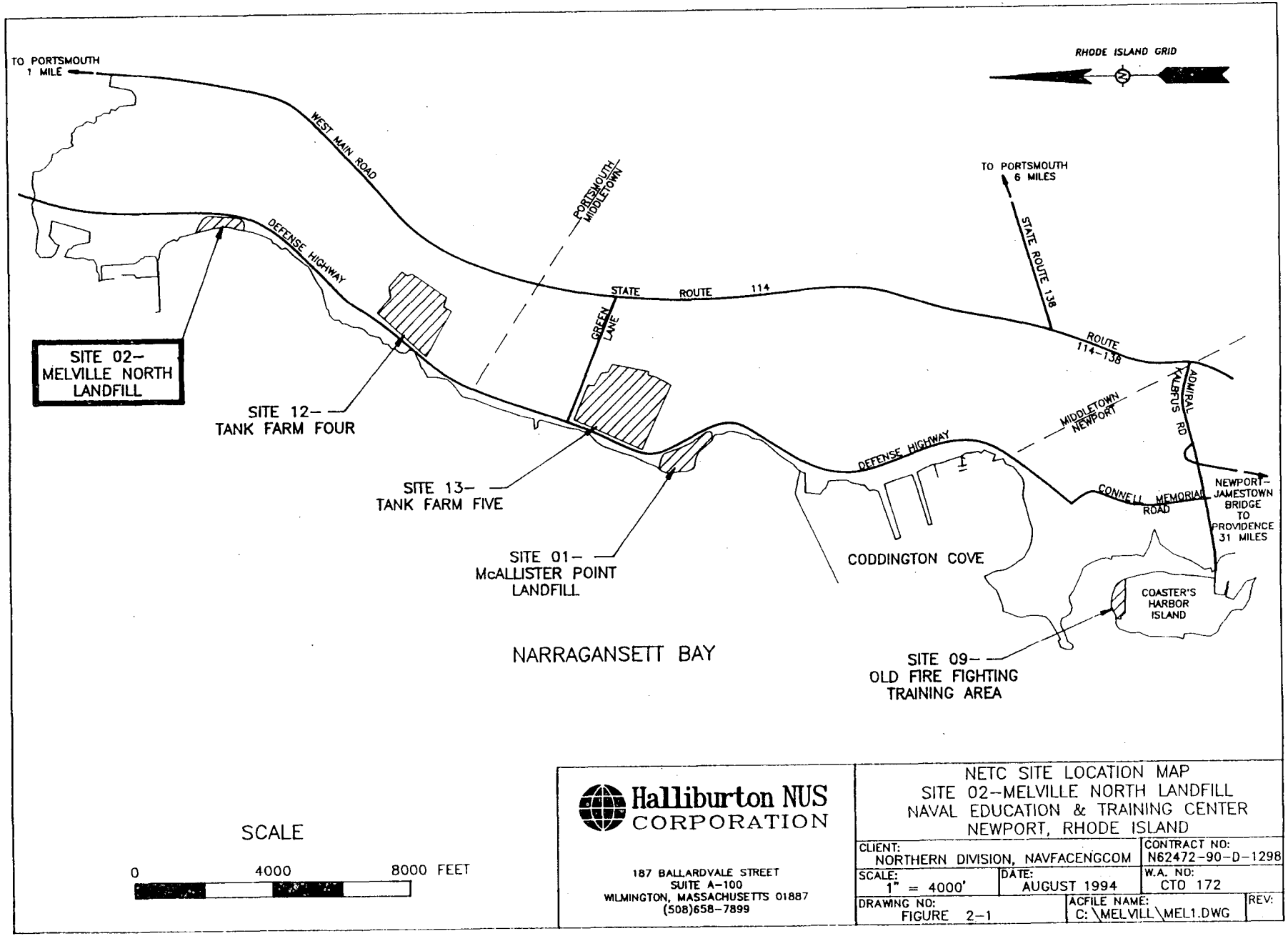
This Health and Safety Plan (HASP) has been prepared by TRC Environmental Corporation (TRC-EC) and amended by Halliburton NUS Corporation (HNUS) for application to a Phase II Remedial Investigation/Feasibility Study (RI/FS) for the Naval Facilities Engineering Command (NAVFAC), Northern Division. The HASP has been specifically developed for the Phase II RI of the Melville North Landfill site located at the Naval Education and Training Center (NETC) in Newport, Rhode Island. Maps of the NETC and the site are provided as Figures 2-1 and 2-2, respectively.

This Health and Safety Plan has been prepared to protect worker health and safety during investigation activities at the Melville North Landfill site. The HASP is intended as an update to the March, 1989 Phase I RI NETC Health and Safety Plan also prepared by TRC-EC. Additional details and information are provided in the Work Plan, specifically the Field Sampling Plan located in Section 4.0 of the Work Plan.

Section 2.0 of the HASP describes the anticipated hazards which may be encountered at the site. Section 3.0 discusses project staffing, organization and responsibilities. Section 4.0 describes regulatory requirements and personnel qualifications. Section 5.0 describes site control measures to be employed at the site to maintain order and minimize chemical and physical hazards to on-site personnel, visitors, and the public. Section 6.0 describes site Health and Safety orientation meetings, and weekly Health and Safety meeting updates. Section 7.0 describes task specific Health and Safety procedures as well as chemical and physical hazards, site monitoring, action levels, personnel protective equipment, and decontamination and disposal procedures. Lastly, Section 8.0 describes emergency procedures, emergency phone numbers, and presents a map of the route to a hospital from the site.

1.1 PROJECT OBJECTIVES

The objective of the Phase II RI/FS of the Melville North Landfill Site are: to define the source areas of contamination; the potential pathways of migration; the potential receptors; and the associated exposure to the extent necessary to: determine whether, or to what extent, a threat to human health or the environment exists; develop and evaluate remedial alternatives (including the non-action alternative; and support future enforcement or cost recovery actions).

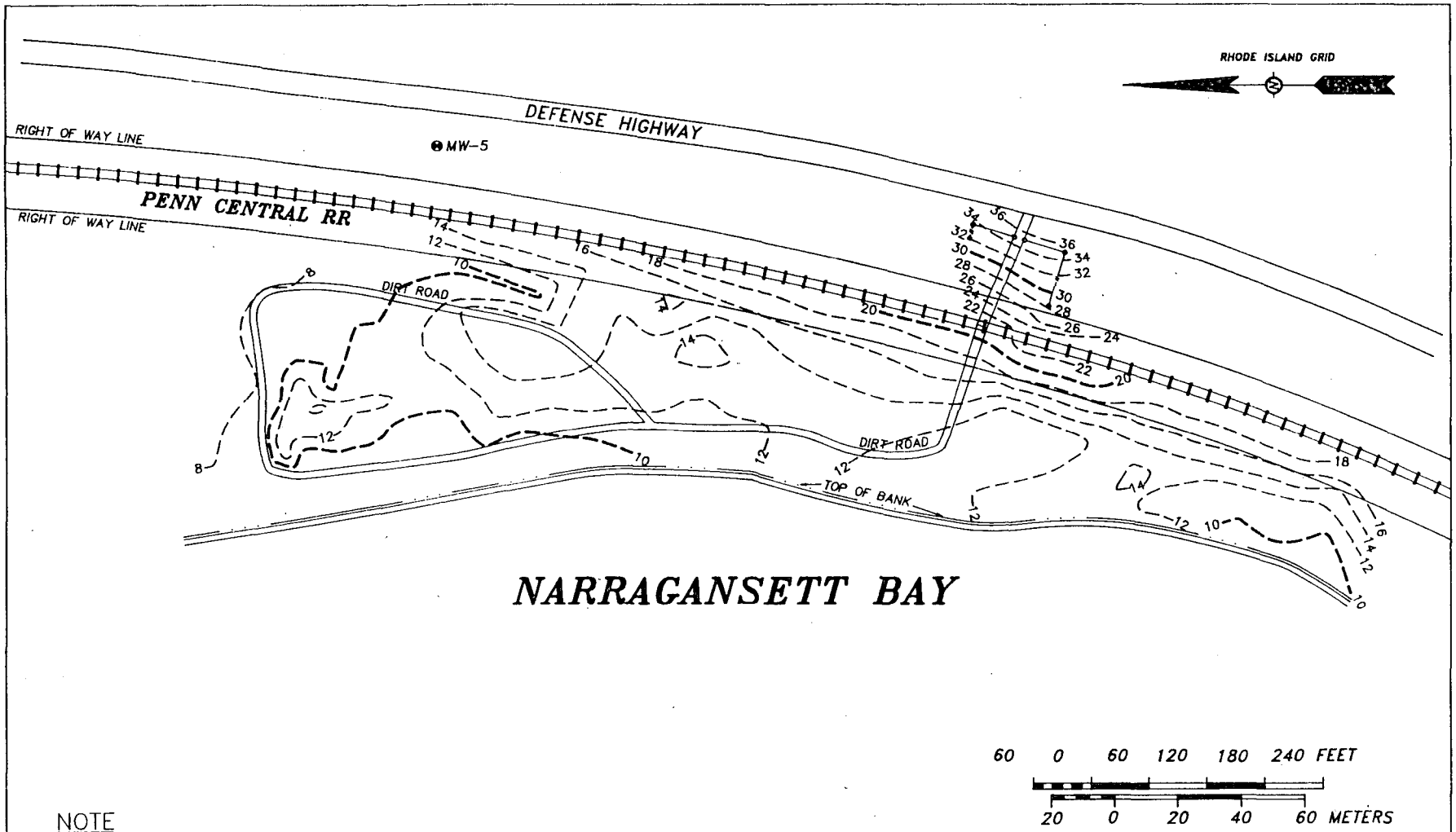


Halliburton NUS CORPORATION

187 BALLARDVALE STREET
SUITE A-100
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

NETC SITE LOCATION MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
SCALE: 1" = 4000'	DATE: AUGUST 1994	W.A. NO: CTO 172
DRAWING NO: FIGURE 2-1	ACFILE NAME: C:\MELVILL\MEL1.DWG	REV:



NOTE

SITE TOPOGRAPHIC SURVEY CONDUCTED IN 1991 AND DOES NOT REFLECT ELEVATION CHANGES CREATED BY 1994 SURFACE SOIL EXCAVATION ACTIVITY.

LEGEND

---10--- CONTOUR LINE (10 FOOT INTERVAL)

--12-- CONTOUR LINE (2 FOOT INTERVAL)

Halliburton NUS CORPORATION

187 BALLARDVALE STREET
SUITE A-100
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

SITE TOPOGRAPHIC SURVEY MAP
SITE 02-MELVILLE NORTH LANDFILL
NAVAL EDUCATION & TRAINING CENTER
NEWPORT, RHODE ISLAND

CLIENT: NORTHERN DIVISION, NAVFACENGCOM		CONTRACT NO: N62472-90-D-1298
SCALE: 1" = 180'	DATE: AUGUST 1994	W.A. NO: CTO 172
DRAWING NO: FIGURE 2-2	ACFILE NAME: C:\MELVILL\MEL11.DWG	REV:

One of the purposes of this HASP is to inform site personnel of the currently known and suspected hazards associated with work at the site. All site personnel, including subcontractors, are required to become familiar with and follow provisions of this plan. Although all employees are required to follow the guidelines set forth herein, the safety of site personnel is ultimately the responsibility of the individual and their respective employers. Copies of this HASP will be available to on-site personnel for orientation to anticipated on-site hazards (based on currently available data), as well as the health and safety procedures to be followed during implementation of this program. HNUS or the Navy cannot be responsible for enforcing provisions of this plan for the health and safety of site personnel other than their own employees.

To meet project objectives, field explorations will include the following activities: ambient air, soil gas and geophysical surveys; soil, sediment, and groundwater sampling; soil boring drilling and monitoring well installation activities; wetlands delineation and surveying; and well hydraulic tests. The field investigation activities planned for Melville North Landfill are described in the Field Sampling Plan provided in Section 4.0 of the Work Plan.

1.2 WORK TASKS

This section summarizes the Phase II field activities planned for the Melville North Landfill site.

1.2.1 Geophysical Surveys

A geophysical survey will be conducted at the site. The geophysical survey will consist of a seismic refraction survey across the site. The seismic survey will be used to determine the bedrock topography at the site.

1.2.2 Soil Sampling

Soil samples will be collected from the site. Soil samples will be collected as both surface and subsurface soil samples. Samples will be concentrated in areas identified through historic information, geophysical surveys, soil gas surveys, and/or the findings of the Phase I RI as areas of potential contamination. The objective of soil sampling will be to assess the nature and extent of soil contamination at the Melville North Landfill site. Each soil sample will also be screened for the presence of total volatile organic vapors/gases with a photoionization or flame ionization detector.

1.2.3 Soil Gas Investigation

A soil gas investigation will be completed at the Melville North Landfill during the Phase II RI. The planned Phase II soil gas investigation is based on the findings of the Phase I RI. The objective of the soil gas sampling is to aid in further investigating the area of subsurface soil and groundwater contamination detected during the Phase I RI.

1.2.4 Monitoring Well Installation and Development

Additional groundwater monitoring wells will be installed and sampled at the Melville North Landfill site in Phase II of the RI. The findings of the Phase I RI indicate the need to further investigate areas of observed groundwater contamination and the background groundwater quality for the site. Thus, the overall objective of the Phase II monitoring well program is to further assess the groundwater quality at the site.

1.2.5 Groundwater Sampling

Groundwater monitoring wells installed at the Melville North Landfill during the Phase I RI and those planned for installation in Phase II will be sampled. Groundwater samples will be collected from all of the wells after they have been properly developed and purged.

1.2.6 Land Survey

Following completion of the field investigation activities, the site sampling locations will be established on a site map. The coordinates and elevations of all sample points will be determined. The site features and topography will also be located during the survey. The objective of the land survey will be to provide a map of the site which shows the main site features and all of the Phase I and Phase II sample locations. The coordinates and elevations of all sampling points will also be tabulated.

1.2.7 Wetland Delineation and Functional Assessment

The wetlands delineation will establish the wetland boundary based upon the three essential characteristics of wetlands: hydrophilic vegetation, hydric soils, and wetland hydrology. The 1987 Federal Manual describes technical criteria for identification of these characteristics. The criteria for all three characteristics must be met for an area to be identified as a wetland. The State of Rhode Island uses a vegetational approach to establish the limits of a wetland. Both methods will be employed to assess whether a particular area meets either set of criteria. This is done by conducting

a field survey of the plants, soils, and general hydrology of on-site and adjacent areas. The wetland scientist will augment the WET 2.0 analysis with an interpretation of results combining the vegetative, soils, and hydrology aspects of the study.

1.2.8 Sediment Sampling

Sediment sampling of the salt marsh located in the northern portion of the Melville North Landfill study area will be conducted as part of the wetlands evaluation during the Phase II RI. The proposed sediment sampling program will provide additional data on the distributions of the wetland sediment contaminants identified during the Phase I RI. Hand augers will be used to obtain soil/sediment samples to a depth of 12 inches.

1.2.9 Well Hydraulic Test

Both rising head and falling head hydraulic (slug) tests will be performed on the four newly installed bedrock wells and on six selected overburden wells in order to help determine the hydraulic characteristics of the aquifer(s) beneath the area of investigation. The overburden wells to be tested will be determined using data (soil classification and pumping response) collected during the soil boring and well installation programs.

2.0 SITE HAZARD SUMMARY

Hazards which may be encountered at this site can be classified into three general categories: chemical, physical, and natural. Chemical hazards are site specific and involve potential exposure to chemical contaminants in soil, groundwater, and volatilized components in air. Physical hazards are generally occupationally specific and involve some type of accident. Natural hazards are created by natural environmental circumstances such as weather, poisonous plants, poisonous animals, insect bites, etc.

2.1 CHEMICAL HAZARDS

A review of the available historic information indicates a number of potential contaminants may be present at the site. Tables 2-1 and 2-2 summarize suspected contaminants at the Melville North Landfill site.

The potential for exposure to site contaminants could result from inhalation, ingestion, or direct contact (skin absorption) with soils or waters contaminated with volatile organic hydrocarbons. Common symptoms of acute exposure to VOCs include headaches, dizziness, nausea, eye irritation, fatigue, loss of coordination, visual disturbances, abdominal pains, and cardiac arrythmia. Chronic exposures to solvents, hydrocarbons, and/or lead can lead to skin diseases; nervous and respiratory system disorders; kidney, liver, brain, and heart malfunctions; and cancer.

Potential contaminants from former site use activities that may be encountered are summarized in Section 2 of the Phase II RI Work Plan. Below is a summary of the known site contaminants based upon the findings of the Phase I RI.

Soil Assessment - Volatile organic compounds (VOCs), base neutral/acid extractable organic compounds (BNAs) (including polynuclear aromatic hydrocarbons (PAHs)), pesticides, PCBs, dioxins, furans, and inorganics were all detected in on-site soils. The major areas of the site where contaminants were detected in the soils at elevated levels include the following:

- Northwestern area - BNAs, PCBs;
- Northeastern area - PCBs, inorganics;
- North-central area - inorganics;
- Central area - VOCs, BNAs, pesticides, PCBs, dioxins, furans, and inorganics; and
- South of access road - VOCs, BNAs, PCBs, and inorganics.

TABLE 1
SUMMARY OF CONTAMINANTS
MELVILLE NORTH LANDFILL

COMPOUND NAME	RANGE OF SURFACE SOIL SAMPLES (mg/kg)	RANGE OF SUBSURFACE SOIL SAMPLES (mg/kg)	RANGE OF GROUND WATER SAMPLES (ug/L)
INORGANICS			
Antimony	4.9–50.4	3.5–1898	ND
Arsenic	2.1–23.4	1.3–35.95	3.3–22.4
Barium	6.5–269	6.7–1360	59.4–759
Beryllium	0.19–0.52	0.16–1.4	1.1–3.8
Cadmium	0.6–1.2	0.51–32.9	10.1–14.7
Chromium	5.1–35.2	4.6–274	5.7–121
Cobalt	3.2–16.7	1.8–74.3	32.9–192
Copper	12.2–206	10.5–24400	32.5–958
Lead	10.2–400.5	1.0–6920	23.5–960
Magnesium	959–4530	709–4180	9690–34400
Mercury	0.14–1.1	.12–2	0.38–1.8
Nickel	6–32.2	4.5–427	126–221
Thallium	0.58–1.6	X0.3–9.1	4
Vanadium	12.5–53.8	7.8–645	137–203
Zinc	29.9–547	20–23935	126–4170
VOLATILES			
1,1–Dichloroethene	X 0.006–0.007	X0.006–0.04	X5
1,1,1–Trichloroethane	X 0.006–0.008	0.006–0.2	X5
1,1,2–Trichloroethane	X 0.006–0.008	X0.006–0.04	X5
1,1,2,2–Tetrachloroethane	0.006–0.008	X0.006–0.04	X5
1,2–Dichloroethane	X 0.006–0.007	X0.006–0.04	X5
1,2–Dichloropropane	X 0.006–0.007	X0.006–0.04	X5
1,3–Dichloropropene (Cis)	X 0.006–0.008	X0.006–0.04	X5
1,3–Dichloropropene (Trans)	X 0.006–0.008	X0.006–0.04	X5
2–Butanone	ND	0.007–1.7	X10
2–Hexanone	0.012–0.016	X0.011–1.6	X10
4–Methyl–2–Pentanone	0.012–0.016	X0.011–1.6	X10
Acetone	0.19	0.24–6.2	X10
Benzene	X 0.006–0.008	0.006–0.32	3–49
Bromodichloromethane	X 0.006–0.008	X0.006–0.04	X5
Bromoform	X 0.006–0.008	X0.006–0.82	X5
Carbon Tetrachloride	X 0.006–0.008	X0.005–0.04	X5
Chlorobenzene	0.006–0.008	0.005–1.5	X5–79
Chloroform	0.006–0.007	X0.006–0.04	X5
Chloromethane	X 0.012–0.014	X0.011–0.079	X10
Dibromochloromethane	X 0.006–0.008	X0.006–0.04	X5

X : Values "UJ" qualified data only
ND : Not Detected

TABLE 1 (continued)
SUMMARY OF CONTAMINANTS
MELVILLE NORTH LANDFILL

COMPOUND NAME	RANGE OF SURFACE SOIL SAMPLES (mg/kg)	RANGE OF SUBSURFACE SOIL SAMPLES (mg/kg)	RANGE OF GROUND WATER SAMPLES (ug/L)
VOLATILES (cont)			
Ethylbenzene	0.006–0.008	0.006–2.3	5–44
Methylene chloride	ND	ND	ND
Styrene	0.006–0.008	X0.006–0.04	X5
Tetrachloroethene	0.001–0.008	0.004–0.04	X5
Toluene	0.002–0.008	0.001–0.72	5–6
Trichloroethene	X 0.006–0.008	0.002–0.04	X5
Vinyl chloride	X 0.012–0.014	0.006–0.079	X10
Xylenes	0.006–0.008	0.003–11.0	5–110
SEMIVOLATILES			
1,3–Dichlorobenzene	ND	1.6	14
1,4–Dichlorobenzene	ND	7.9	83
2–Methylnapthalene	0.12–1.2	0.1–24.0	9–210
2,4–Dinitrophenol	ND	X11.0	ND
3–Nitroaniline	ND	X2.0–13.0	ND
3,3'–Dichlorobenzidine	ND	X0.79–5.2	ND
Acenaphthene	0.047–0.37	0.12–5.5	17
Acenaphthylene	0.045–1.5	0.410–2.2	ND
Anthracene	0.078–2.0	0.066–4.0	12
Benzo(a)anthracene	0.087–9.8	0.074–6.8	ND
Benzo(a)pyrene	0.081–7.5	0.059–5.6	ND
Benzo(b)fluoranthene	0.069–6.4	0.078–4.8	ND
Benzo(ghi)perylene	0.2–3.4	0.06–3.7	ND
Benzo(k)fluoranthene	0.081–6.8	0.062–3.6	ND
Bis(2ethylhexyl)phthalate	ND	X0.4–2.1	13
Chrysene	0.057–11.0	0.044–6.4	ND
Dibenzo(a,h)anthracene	0.022–1.6	0.40–2.1	ND
Fluoranthene	0.068–15.0	0.053–18	ND
Fluorene	0.064–2.5	0.12–10.0	ND
Indeno(123cd)pyrene	0.24–3.3	0.081–3.2	ND
Naphthalene	0.046–0.45	0.068–17.0	7–100
Phenanthrene	0.048–14.0	0.067–28.0	11–62
Phenol	ND	0.22–0.33	ND
Pyrene	0.057–15.0	0.041–15.0	20

X : Values "UJ" qualified data only
ND : Not Detected

TABLE 1 (continued)
SUMMARY OF CONTAMINANTS
MELVILLE NORTH LANDFILL

COMPOUND NAME	RANGE OF SURFACE SOIL SAMPLES (mg/kg)	RANGE OF SUBSURFACE SOIL SAMPLES (mg/kg)	RANGE OF GROUND WATER SAMPLES (ug/L)
PESTICIDES			
4,4'-DDD	0.005	0.0056	ND
4,4'-DDE	0.0062-0.13	0.0024-0.0047	ND
4,4'-DDT	0.018-0.45	0.0036-0.017	ND
PCB's			
Aroclor-1260	0.043-8.0	0.24-27.0	0.22-40

X : Values "UJ" qualified data only
ND : Not Detected

TABLE 2
US NAVY – NETC
Mellville North Landfill

DIOXIN/FURAN RESULTS (ng/g or ppb)

Sample ID	SS–1	SS–2	SS–5	SS–11	TP–1	TP–4	TP–7	2,3,7,8–TCDD
Depth Interval (1)	0–0.5	0–0.5	0–0.5	0–0.5	3.5 ft. Base of Test Pit	1.5–2.5 Southern wall	3–4 Wall of Test Pit	Equivalency Factors (2)
Soil Description	Black Fine Sand and Silt, Some Organics	Loose, Black Fine Sand and Silt	Soft, Orange Silt Some Organics (0–3") Grey Silt, Trace Sand and Organics (3–6")	Fine Sand, Trace Silt (0–3"), Black Fine Sand and Silt, Some Gravel	Black oily soil observed at base of test pit, ground water observed at 3.5 ft. with an oily sheen. Appears to verify suspect former waste oil lagoon. (OVA = >1,000 ppm)	Orange–rust Sand, Metal and wood Fill, Layer of burned paper at 2', drum carcass found at western end of test pit (2–4' sample description)	Rusty–Orange Fill, debris, Cable, Bottles, wood, medium to coarse brown Sand, little gravel	
Dioxins								
2,3,7,8–TCDD								1.0
TCDD							0.2	0
PeCDD							0.4	0.5
HxCDD					0.8		1.5	0.1
HpCDD	0.2	0.4			2.5	4.2	3.2	0.01
OCDD	4.1	3.7	2.3	3.5	5.0	17	4.7	0.001
Furans								
2,3,7,8–TCDF					0.5	0.2	0.8	0.1
TCDF					1.9	0.2	3.7	0
PeCDF					1.6		3.2	0.5
HxCDF					1.3		2.2	0.1
HpCDF		0.2		1.3	1.1		1.3	0.01
OCDF	0.1	0.1			0.6	0.2	0.5	0.001
Total 2,3,7,8–TCDD Equivalent	**0.0062**	**0.0098**	**0.0023**	**0.0165**	**1.107**	**0.0792**	**2.3047**	

Notes:

1. The depth interval is reported in feet below ground surface.
2. The 2,3,7,8–TCDD Equivalency Factors were taken from the March 1989 update of "Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo–p–dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update". Where isomer specific results are not available, the most conservative equivalency factor (the highest) is applied to that isomer grouping.
3. The following abbreviations are used:

2,3,7,8–TCDD = 2,3,7,8 Tetrachlorodibenzo–p–dioxin
TCDD = Sum of all Tetrachlorodibenzodioxin isomers
PeCDD = Sum of all Pentachlorodibenzodioxin isomers
HxCDD = Sum of all Hexachlorodibenzodioxin isomers
HpCDD = Sum of all Heptachlorodibenzodioxin isomers
OCDD = Sum of all Octachlorodibenzodioxin isomers

2,3,7,8–TCDF = 2,3,7,8 Tetrachlorodibenzofuran
TCDF = Sum of all Tetrachlorodibenzofuran isomers
PeCDF = Sum of all Pentachlorodibenzofuran isomers
HxCDF = Sum of all Hexachlorodibenzofuran isomers
HpCDF = Sum of all Heptachlorodibenzofuran isomers
OCDF = Sum of all Octachlorodibenzofuran isomers

Significant VOC contamination (i.e., greater than 1 ppm total VOCs) was detected in subsurface soils in the central portion of the site, in the suspected area of former lagoons, and in the southern portion of the site at well boring 4. Soil samples collected in the former lagoon area and from well boring 4 generally exhibited strong petroleum odors and/or visible oil contamination. BNAs were detected at elevated levels (i.e., greater than 10 ppm total BNAs) in the northwest, central and southern portions of the site.

Pesticides were detected at low levels (i.e., 10's of ppb) in surface soil samples across the site with higher levels (100's of ppb) detected in the central portion of the site. PCBs were detected in surface and subsurface soils. PCBs were detected above the 10 ppm RIDEM PCB soil action level in surface soils in the northwest and northeast portions of the site, and in subsurface soils in the central and southern portions of the site.

Dioxins/Furans were detected at concentrations below calculated human health risk values in soil samples collected at the surface and at depth.

Inorganics were detected in soil samples collected from the northeast corner of the site to just south of the site access road at levels exceeding background levels. The highest inorganic levels were detected in subsurface soils generally collected at or below the water table from the north-central and central to south-central portions of the site.

Groundwater Assessment - VOCs, BNAs, pesticides, PCBs, and inorganics were all detected in groundwater samples. The major areas of the site where contaminants were detected at levels exceeding action levels include the following:

- North-central area - inorganics;
- Central area - VOCs, and inorganics; and
- South of access road - VOCs, BNAs and PCBs.

VOC detections at concentrations exceeding groundwater action levels, consisting mostly of petroleum-related VOCs (xylene, benzene), were limited to wells located in the central (MW-3) and southern (MW-4) portions of the site. Oil was also identified in well MW-3. VOCs were also detected in soil boring samples collected at the depth of the water table from the central and southern portions of the site, and signs of petroleum related contamination (e.g., odors, oil) were observed during the drilling and sampling of these borings. One BNA compound was detected above groundwater action levels in a well (MW-4) in the southern portion of the site. A pesticide, gamma-BHC, was detected in groundwater at well MW-4.

A PCB concentration of 40 ppb was also detected in well MW-4 (PCBs were detected in the soil from this well boring). PCBs were also detected at 0.13 ppb, less than the MCL, in MW-3 in the central portion of the site. While inorganic concentrations exceeded groundwater action levels in most wells, the highest levels of inorganic analytes were detected in groundwater in the central to north-central portions of the site.

Sediment Sample Assessment - VOCs, BNAs, pesticides, and inorganics were detected in sediment samples. The sediment samples were collected from the swampy area at the northern edge of the site. The contaminants detected at elevated levels in the sediment included carcinogenic PAHs, pesticides, and inorganics.

The maximum total VOC concentration detected in the sediment was 11 ppb, well below the contaminant-comparison level of 1 ppm. The maximum total BNA concentration detected was 5.43 ppm, also below the contaminant-comparison level of 10 ppm. However, total carcinogenic PAH levels in two samples exceeded the contaminant-comparison level of 1 ppm. Pesticides were detected in each of the sediment samples, with 4,4'-DDE detected at each location at concentrations ranging from 7.9 to 470 ppb. Inorganic analytes were detected at elevated concentrations at each sample location, although different analytes exceeded background at each location.

The complete list of contaminants of concern at the Melville North Landfill site, as determined in the Phase I Human Health Risk Assessment, is provided in Table 2-1 and 2-2.

2.2 PHYSICAL HAZARDS

Primary physical hazards at the site are those associated with drilling activities. Hazards that could be encountered during subsurface explorations include contacting or puncturing an underground line or utility, falls and trips, injury from lifting heavy objects, falling objects, eye injuries, head injuries, and pinched or crushed hands and feet. A fire hazard may also be present due to the use of gasoline-powered equipment, and the possible presence of flammable materials in subsurface soils. Dig Safe must be contacted and a thorough underground utilities search must be conducted before the commencement of any intrusive earthwork.

2.3 NATURAL HAZARDS

Natural hazards such as weather, poisonous plants, animals, and insects cannot always be avoided. Based on available information and current site conditions, the site safety officer and field personnel shall use their best judgement to avoid these potential hazards.

Natural hazards also include exposure to adverse weather conditions including heat and cold stress. Methods of symptom recognition, preventive measures, and first aid methods for cold and heat stress are provided as Attachment A to this HASP.

3.0 STAFF RESPONSIBILITIES

3.1 PROJECT STAFF RESPONSIBILITIES

HNUS staff listed below will be responsible for the respective activities listed.

3.1.1 Project Manager

- Provides overall project management and control.
- Maintains day-to-day liaison with NETC Environmental Coordinator and subcontractors.
- Notifies NETC Environmental Coordinator of any site emergencies.
- Prepares, reviews, and transmits project documents to the Navy.
- Conducts the initial site orientation.

3.1.2 CLEAN Health and Safety Manager

- Assists in the development and review of the HASP.
- Provides on-going industrial hygiene support to the Project Manager and HSO.
- Reviews and approves significant changes and/or deviations to the HASP.
- Provides consultation to the Project Manager and HSO on technical aspects of the HASP and its implementation.

3.1.3 Health and Safety Officer

- Development of the HASP and any Addendums.
- Provides guidance and health and safety support to the Project Manager and Site Safety Officer.
- Ensures implementation and adherence to the HASP.
- Conducts the initial health and safety site orientation.
- Reports on any incident or accident to the appropriate parties.
- Conducts field Health and Safety audits.

3.1.4 Field Operations Leader

- Coordinates and supervises fieldwork.
- Reports daily progress of fieldwork to the Project Manager.

- Notifies Project Manager of deviations from the Health and Safety Plan.
- Ensures that fieldwork proceeds according to Health and Safety Plan requirements.

3.1.5 Site Safety Officer (SSO)

- Primary responsibility for notification of and transport of injured field personnel to a hospital in the event of an accident.
- Monitors field investigations to ensure compliance with the approved HASP.
- Recommends modification of the HASP to the HSO and Project Manager as soon as practical after it is apparent that the Plan should be modified.
- Keeps non-essential personnel outside study zone boundaries. Logs in the field notebook personnel who enter into the study zone.
- Appoints alternate SSO on an as needed basis.
- Uses appropriate portable field instruments to monitor site conditions during investigatory activities.
- Maintains a log of field activities, monitoring data, and site meetings.

3.1.6 SSO - Alternate(s)

- Assumes all functions and responsibilities of the SSO in his/her absence.

3.1.7 Subcontractors

- Immediately notify the Field Team Leader or Site Safety Officer of hazardous or potentially hazardous conditions or environments that are not addressed or not adequately addressed in the HASP.
- Conduct work in a safe manner.
- Adherence to all HASP requirements.

4.0 REGULATORY REQUIREMENTS AND PERSONNEL QUALIFICATIONS

To be authorized for field explorations, HNUS field personnel and subcontractor field personnel (e.g., drilling and soil gas contractors, etc.) must meet the minimum requirements described in these subsections. Documentation of the requirements described below for HNUS personnel will be maintained by HNUS for personnel involved in field activities. Subcontractors and regulatory personnel are responsible for maintaining the required documentation for their field personnel.

4.1 MEDICAL MONITORING

In compliance with OSHA medical monitoring regulations (29 CFR 1910.120), field supervisory personnel and field sampling personnel shall have received an examination by a licensed occupational physician. The most recent exam shall have been received within the 12-month period proceeding this work, and each employee shall have been determined by the attending physician to be physically able to perform the work and to use respiratory and other protective equipment as required for field investigations.

4.2 HEALTH AND SAFETY TRAINING

Field personnel shall have received training and/or experience which, at a minimum, satisfies the OSHA regulations for hazardous waste and emergency response (29 CFR 1910.120). This includes current certification in the 40 Hour Hazardous Waste and Emergency Response, 8 Hour Annual Refresher, and the Supervisory training (as applicable).

4.3 RESPIRATOR TRAINING

All personnel who enter the Exclusion Zone shall have completed a respiratory protection program which, at a minimum, satisfies the OSHA regulations (29 CFR 1910.134). This program shall include: 1) instruction in the proper use and limitations of respirators; 2) proper fitting of personnel for a respirator, using a qualitative or quantitative fit test method; and 3) teaching personnel how to conduct a positive and/or negative pressure fit test. The respirator which is used to fit test personnel will be individually assigned and available for site work.

HNUS provides respiratory protection to employees involved in activities at work locations where the presence of respirable hazards is known or suspected.

Field staff assigned to this project shall be capable of using and inspecting a cartridge respirator. All field staff shall have their own personal respirator. The maintenance of that respirator shall be the responsibility of the individual. OSHA requires that respirators be inspected both before and after use and that respirators not used routinely shall be inspected after use and at least monthly. At the time the respirator is issued and used, the individual receiving it shall test the fit (qualitatively), and inspect the gaskets, exhalation valve, face shield, head straps, and cartridges. Individuals are responsible for cleaning/disinfecting their respirators. Acceptable procedures include washing using respirator-approved detergent/disinfectant in warm water and rinsing or air drying in a clean place. Respirators will be used on a site specific basis as described in Section 7.0 of this HASP.

5.0 SITE ACCESS AND CONTROL

The Melville North Landfill site consists of a parcel of land approximately 8 acres in size located just off of Defense Highway and adjacent to Narragansett Bay. Access to the site is off of Defense Highway through a gate and along a small paved road. The paved road leads down a small hill, over railroad tracks, and to the site which is along the waterfront.

The purpose of the site control measures presented in this section are to maintain order at the site and to minimize chemical and physical hazards to on-site personnel, visitors, and the public. Three work zone/areas will be established for the site: a support zone, a decontamination zone, and an exclusion zone. The site-specific access considerations and work zones established for each of the site investigations are presented in the Field Sampling Plan in Section 4.0 of the Work Plan. Below are general descriptions of each of the three work zones.

5.1 SUPPORT ZONES

The support zones are considered "clean areas" and provide areas or locations where field personnel can take breaks and store field investigation equipment. The support zones also contain site safety and emergency supply equipment (e.g., first aid kits, eye wash units, HASP) and field communication equipment (e.g., mobile phone, walkie talkie).

The support zone will consist of the on-site personnel vehicles and field office trailer. This field office trailer will be the command center for the site field investigation activities. The field investigation team will be provided with communication equipment (e.g., mobile phone, walkie talkie) for maintaining contact with the field office trailer.

5.2 EXCLUSION ZONES

During the field investigation activities, the exclusion zone will consist of the entire site outside of the adjoining support and decontamination zones. At the off-site investigation locations (e.g., monitoring well locations), the exclusion zone will consist of a 25-foot area surrounding the active investigation operations (e.g., drilling).

The SSO or alternate will be responsible for keeping nonessential personnel outside the exclusion zone boundaries. In the event that visitors or unauthorized personnel are present during field activities, the SSO or alternate shall verbally request that they maintain a safe distance outside of the exclusion zone.

Prior to entering the exclusion zone, site personnel shall have donned the proper personnel protective equipment (PPE) for expected site conditions, as outlined in Section 7.0 of this HASP, or as determined by the SSO or alternate.

5.3 DECONTAMINATION ZONE

A contamination reduction station, or decontamination zone, will be established adjacent to the exclusion zone. The decontamination zone will be established at the upwind side of the exclusion zone and will consist of a taped off area adequate in size to comfortably contain decontamination equipment. Personnel exiting the exclusion zone shall undergo appropriate decontamination, if required by the task-specific procedures described in Section 7.0 of this HASP. A heavy equipment (e.g., drill rigs, augers, rods) decontamination area for the site will be located in a central area to site operations. Disposal of investigation derived waste materials will be in accordance to the Work Plan.

6.0 GENERAL HEALTH AND SAFETY WORK PRECAUTIONS

6.1 HEALTH AND SAFETY SITE ORIENTATION

All site investigation personnel shall be required to read this HASP and attend the Health and Safety Site Orientation meeting. Documentation of attendees will be recorded using Figure 6-1 and maintained as part of project records. The HASP will accompany field personnel to each site and shall be maintained at a location known to each individual working on-site.

The HSO will conduct a health and safety site orientation prior to the initiation of field activities. The orientation will cover all aspects of this HASP. Particular emphasis will be placed on a review of potential site contaminants and their potential health effects; accident prevention; safe work procedures; precautionary measures; use of personal protective equipment; and emergency response procedures. All field staff are required to attend.

6.2 HEALTH AND SAFETY BRIEFINGS

The SSO or alternate will conduct a Health and Safety briefing on a routine basis. Topics to be covered include personnel protective equipment, personal and equipment decontamination procedures, accident prevention, and any modifications or amendments to the Health and Safety Plan. All field staff are required to attend. Documentation of the meeting and personnel attending each meeting will be maintained in project files.

FIGURE 6-1
HASP REVIEW FORM

My signature below indicates that I am aware of the potential hazardous nature of performing activities at the Melville North Landfill located in Newport, Rhode Island and that I have reviewed the Health and Safety Plan prepared for the RI/FS activities. I have also received site-specific training which included the items presented below:

- Names of Personnel and alternates responsible for site safety and health
- Hazards presented by working at the site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the Health and Safety Plan and Attachments

I further state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction.

Name	Signature	Date

7.0 TASK-SPECIFIC HEALTH AND SAFETY PROCEDURES

7.1 GENERAL

The following general health and safety procedures will be employed for work conducted at the Melville North Landfill site.

7.1.1 Chemical and Physical Hazards

The activities which do not involve subsurface activities (geophysical and land surveys) could result in the exposure of workers to contaminated surface soils or vapors. Such an occurrence can lead to worker exposure via inhalation or permeation through the skin (skin absorption). However, in general, non-invasive activities do not require direct contact with site soils and/or waters, and therefore exposures are anticipated to be minimal.

7.1.2 Site Monitoring

The SSO shall use an HNu PI-101 (or equivalent) photoionization detector (PID), with a 10.2 eV lamp, or an OVA 128 (or equivalent) flame ionization detector (FID) to monitor organic vapors in the breathing zone at the upwind boundary of the Exclusion Zone at the beginning of each day, to establish a daily background reading.

The federal regulation 20 CFR Part 1910.120 (h)(2-3) indicates air monitoring is required upon initial entry, and periodic monitoring shall be conducted when the possibility of an immediately dangerous to life and health (IDLH) condition exists or when there is an indication that exposures may have risen over permissible or published limits since prior monitoring. The air monitoring program conducted on site is intended to be consistent with these requirements.

7.1.3 Action Levels

All field work will begin in personal protective gear as defined in Section 7.1.4 of this HASP. Based on the PID/FID readings in the breathing zone, or site conditions, the SSO shall upgrade or downgrade Personal Protective Equipment (PPE) requirements as described below.

The following action levels are based on PID/FID breathing zone readings:

- 0 to 1 unit above background: Level D
- 1 to 5 units above background for longer than one minute: Modified Level D
- 5 to 25 units above background: Level C
- 25 units or greater: discontinue operations. Make arrangements to continue work in Level B protective equipment or use Level B to retrieve/demobilize equipment.

The SSO may also make the decision to upgrade the PPE requirements, even if positive PID/FID readings are not noted. This decision will be based on site conditions including visual or sensory observation of soil or groundwater contamination, or other site hazards.

Action levels were set below the PEL's/TLV's of the most abundant substances suspected at the sites.

7.1.4 Personal Protective Equipment (PPE)

This section contains specific provisions for the use of Personal Protective Equipment (PPE). It shall be the responsibility of the SSO to make the determination of the level of PPE to be used by personnel within the Exclusion Zone. The decision of the SSO will be based on site monitoring (HASP - Section 7.1.2), action levels (HASP - Section 7.1.3), knowledge of the site, and observed site conditions. Changes affecting the level of PPE defined in the HASP will be at the direction and approval of the HNUS HSO or SSO.

The following is a discussion of the anticipated levels of personal protection based upon historical information and the findings of the Phase I RI.

Level D personal protection will be used at the start of most non-intrusive field work (e.g., surveying, geophysics). Level D protection shall include use of the following items:

- work clothes;
- hard hat;
- work boots; and
- chemical protective gloves when collecting soil and water samples (viton/nitrile).
- inner glove liners (latex/vinyl)
- hearing protection (as needed)

Level D protection may also include the use of a polycarbonate faceshield, attached to the hard hat, in the event that potential splash conditions are present. Splash conditions are most likely to be

present during decontamination of heavy equipment. Use of the splashguard shall be at the discretion of the SSO.

A Modified Level D, which includes Level D plus additional PPE (e.g., tyvek, boot covers), will be used during subsurface investigation or intrusive activities (drilling, soil gas).

An upgrade to Level C may be necessary if the concentration of VOCs detected in the breathing zone of the workers exceeds the action level of 5 PID/FID units discussed in Section 7.1.3 of this HASP, or if warranted by other site conditions. Level C protection will include all of the PPE required for Modified Level D plus appropriate respiratory protection. The specific respirator to be used for Level C protection shall be a NIOSH-approved full-face respirator with compatible GMC-H cartridges. Respirator cartridges will be changed at the first sign of breakthrough, or daily at a minimum, when in use.

It is anticipated that protective Level D or Modified Level D will be appropriate for carrying out most work tasks related to this project. A sufficient inventory of necessary equipment will be maintained on-site to provide these levels of protection for all site personnel who must work within the Exclusion Zone.

7.1.5 Decontamination

Upon leaving the Exclusion Zone, personnel must undergo appropriate decontamination. The nature of the decontamination requirements will depend on the nature of the work conducted and whether immediate re-entry into the Exclusion Zone is planned, or if complete egress from the Exclusion Zone is intended.

The personnel decontamination requirements will also depend on the level of protection used within the Exclusion Zone and the suspected degree of contamination. This area will be located immediately outside the access opening of the Exclusion Zone on its apparent upwind side. This area shall contain the decontamination station necessary to allow rest breaks and respirator cartridge changes (if appropriate), as well as for complete decontamination as required for food and beverage breaks, or exiting the work area. Periodic air monitoring will be conducted in the contamination reduction zone (decontamination area) when this area is used.

Equipment decontamination will occur in designated areas. Field decontamination of other sampling equipment will occur at locations designated for the site. Most of the field sampling equipment (e.g., spoon, bailers) will be laboratory decontaminated to, in part, reduce the amount of field-generated

waste. The equipment decontamination procedures are described in the QAPP in Section 5 of this Phase II RI Work Plan.

7.1.6 Field Generated Waste Handling

The handling of materials generated during site activities (e.g., drill cuttings, purge/development water, PPE) will be conducted as described in the Work Plan. All site visitors (e.g., regulators, auditors) shall dispose of their expendable PPE along with that of the field investigation personnel.

7.2 GENERAL SITE MEDIA SAMPLING

This section describes the health and safety considerations for all general or non-intrusive site sampling activities. Such activities would include surface soil sampling, sediment sampling, and groundwater sampling.

7.2.1 Chemical Hazards

General non-intrusive media sampling activities at the site will include the collection of the following sample types: surface soil, sediment, and groundwater. These activities may result in the exposure of workers to potentially contaminated soils/sediments and groundwater, washwater from decontamination of personnel protective equipment, and vapors released from site media. Such an occurrence can lead to worker exposure via inhalation, ingestion, and permeation through the skin (skin absorption). Proper PPE and monitoring will be used during the field investigation activities to reduce the potential for chemical exposures.

7.2.2 Site Monitoring

During non-intrusive sampling activities, the SSO or designee shall use a PID/FID to monitor the following:

- At each soil sampling point or monitoring well prior to sampling.
- The site workers breathing zone continuously during active sampling activities.

7.2.3 Action Levels

Unless otherwise determined by SSO, Level D protection will generally be used for non-intrusive media sampling tasks. However, for groundwater sampling activities, a minimum of Modified Level D protection will be used by sampling personnel. Based on PID/FID readings measured in the breathing zone or site conditions, the SSO shall upgrade or downgrade PPE requirements.

Action levels to be used for media sampling activities were previously outlined in Section 7.1.3.

7.2.4 Personal Protective Equipment (PPE)

Based on site conditions and action levels described in Section 7.1 of the HASP, the SSO shall upgrade PPE requirements commensurate with site hazards. The SSO may also make the decision to upgrade or downgrade the PPE requirements, even if positive PID/FID readings are not noted. This decision will be based on site conditions including visual or sensory observations of potential contamination. In particular, the presence of free product or other contaminants in groundwater, soil, or sediment may require an upgrade of PPE requirements.

7.2.5 Exclusion Zone

In recognition of the increased risk to workers of exposure to contaminated soils or groundwater, a secondary exclusion zone of approximately 10 feet will be established around all sampling activities. Nonessential personnel shall be prohibited from entering the secondary exclusion zone. Monitoring results will be considered when establishing exclusion zone boundaries. In general, if elevated readings are encountered, the exclusion zone will be enlarged from that described in the plan and if no detectable readings are encountered the exclusion zone will remain as described above.

7.3 SUBSURFACE EXPLORATION/INTRUSIVE ACTIVITIES

7.3.1 Chemical and Physical Hazards

Subsurface exploration or intrusive activities include soil boring activities. These activities may result in the exposure of workers to potentially contaminated soils and groundwater, washwater from decontamination of personnel protective equipment, and vapors released from contaminated site media. Such an occurrence can lead to worker exposure via inhalation, ingestion, and permeation through the skin (skin absorption).

7.3.2 Site Monitoring

The SSO shall use a PID or FID to:

- Monitor organic vapors in the breathing zone at the upwind boundary of the Exclusion Zone at the beginning of each day, to establish a daily background reading.
- Monitor organic vapors in the worker's breathing zone during active subsurface explorations.
- Monitor the workers breathing zone at fifteen-minute intervals or continuously during active subsurface explorations, if elevated levels of organic vapors are detected.
- Monitor the borehole during split spoon sampling activities.

Other monitoring equipment will include an combustible gas/oxygen meter to monitor the ambient air and downhole vapors to monitor for explosive vapors and oxygen content.

7.3.3 Action Levels

Unless otherwise determined by the SSO, Modified Level D protection shall be used for the site subsurface exploration tasks (e.g., drilling, soil gas). Based on positive PID/FID readings in the breathing zone or site conditions, the SSO shall upgrade PPE requirements, as appropriate.

Action levels to be used for subsurface exploration activities are outlined in Section 7.1.3 of the HASP. Additional action levels for the combustible gas/oxygen meter are as follows:

- If airborne concentrations of flammable vapors exceed 10 percent of the lower explosive limit (LEL), retreat immediately to an unaffected area until vapors subside or appropriate corrective actions (e.g., ventilate hole, abandonment and backfill boring) will be taken.

7.3.4 Personal Protective Equipment (PPE)

Based on site conditions and action levels described in Section 7.1.3 above, the SSO shall upgrade or downgrade PPE requirements commensurate with site hazards. The SSO may also make the decision to upgrade the PPE requirements, even if positive PID/FID requirements are not noted.

This decision will be based on site conditions including visual or sensory observations of potential contamination.

During initial subsurface exploration activities and well installation activities, Modified Level D protection will be required. Necessary equipment for Modified Level D protection will include that of Level D plus the additional PPE listed below:

- safety glasses and hard hat (within a 20 foot radius of the drill rig);
- chemically resistant boots, PVC/rubber overboots, or disposable boot covers;
- Tyvek or equivalent jump suit (with ankles and wrists duct taped);
- chemically protective outer gloves (solvex/nitrile); and
- inner glove liners (latex/vinyl).

If odorous soils are detected during subsurface explorations the following procedures will be instituted:

- if PID or FID readings of auger spoils are consistently above 5 PID units, the air monitoring frequency will be increased; and,

- a change, if necessary, to the appropriate PPE will occur.

7.3.5 Exclusion Zone

In recognition of the increased risk of physical injury and exposure to chemical contaminants during subsurface investigation activities, a secondary exclusion zone of a minimum of approximately 25 feet shall be established around exploration equipment (i.e., drill rig, backhoe). Nonessential personnel shall be prohibited from entering the exclusion zone. All personnel entering the exclusion zone will be required to wear appropriate personnel protective equipment.

8.0 EMERGENCY RESPONSE

8.1 EMERGENCY INFORMATION

A list of emergency phone numbers is presented as Figure 8-1 and will be maintained at the site during active investigation activities. In addition, a copy of this HASP will accompany field personnel to the site and shall be maintained at a location known to each individual working on-site.

The Newport Hospital is the nearest medical facility. Directions to the hospital and a map to the hospital are provided in Figures 8-1, 8-2 and 8-3.

The Newport Hospital will accept and treat (to the extent it is capable) workers exposed to various suspect substances or physically injured at the project site.

In the event of a site emergency, the SSO or alternate shall evacuate site personnel to a safe area and then contact the appropriate authorities listed above. As soon as practical, after contacting the authorities and ensuring the safety of site personnel, the SSO shall contact the HNUS HSO and Project Manager.

8.2 GENERAL PROCEDURES

An OSHA approved first aid kit, eye wash bottles, and a fire extinguisher rated for Class A, B and C fires will be present within or near the Exclusion Zone during subsurface explorations. It shall be the responsibility of the SSO to make a determination as to the proper response for a particular emergency. As soon as practical after emergency response, the SSO shall brief the HSO and Project Manager as to the nature of the incident, and response actions taken. The SSO, Project Manager, and HSO, shall evaluate the site conditions and make a determination regarding any measures that could be taken in the future to prevent incidents of a similar nature from being repeated. The Project Manager shall notify the NETC Environmental Coordinator regarding site emergencies.

FIGURE 8-1
EMERGENCY AND SITE PERSONNEL CONTACTS

EMERGENCY CONTACTS

NETC Emergency Numbers:

Command Duty Officer	(401) 841-3456 or 3457
Security Office - Police	(401) 841-3241
NETC Fire Protection	(401) 841-3333
Public Works Trouble Desk	(401) 841-4001

Utilities:

Rhode Island Dig Safe	800-225-4977
NETC Dig Safe	(401) 841-2464

Newport Emergency Numbers:

Portsmouth Police Dept.	(401) 683-0300
Portsmouth Fire Dept.	(401) 683-1200

Newport Hospital

General Number	(401) 846-6400
Emergency Room	(401) 846-6400 ext. 1120
Poison Control Center	(401) 277-5727

Directions to the Newport Hospital:

- From the Melville North Landfill, take a right onto Defense Highway.
- Take a left onto Green Lane to end.
- Take a right onto Route 114 (West Main Rd.).
- Merge with Route 138 and continue straight.
- Follow Rt. 114/138 until road bears slightly right and becomes Broadway.
- Newport Hospital will be on your left at the intersection with Friendship Street.

U.S. Navy

- Northern Division Code 1823
  Naval Facilities Engineering Command
  10 Industrial Highway, Mail Stop #82
  Lester, PA 19113

  Ms. Deborah Carlson, Engineer-In-Charge
  (215) 595-0567

FIGURE 8-1
EMERGENCY AND SITE PERSONNEL CONTACTS
PAGE TWO

- Naval Education and Training Center
  Public Works Dept., Bldg. 1
  Newport, RI

  Mr. Brad Wheeler
  (401) 841-3735

Rhode Island DEM

- Air and Hazardous Materials Division
  291 Promenade Street
  Providence, RI 02908

  Mr. Paul Kulpa
  (401) 277-2797

HNUS

- Halliburton NUS Corporation
  993 Old Eagle School Road, Suite 415
  Wayne, Pennsylvania 19087-1710

  Mr. John J. Trepanowski P.E., Program Manager
  Mr. Mike Turco, Deputy Program Manager
  (610) 971-0900

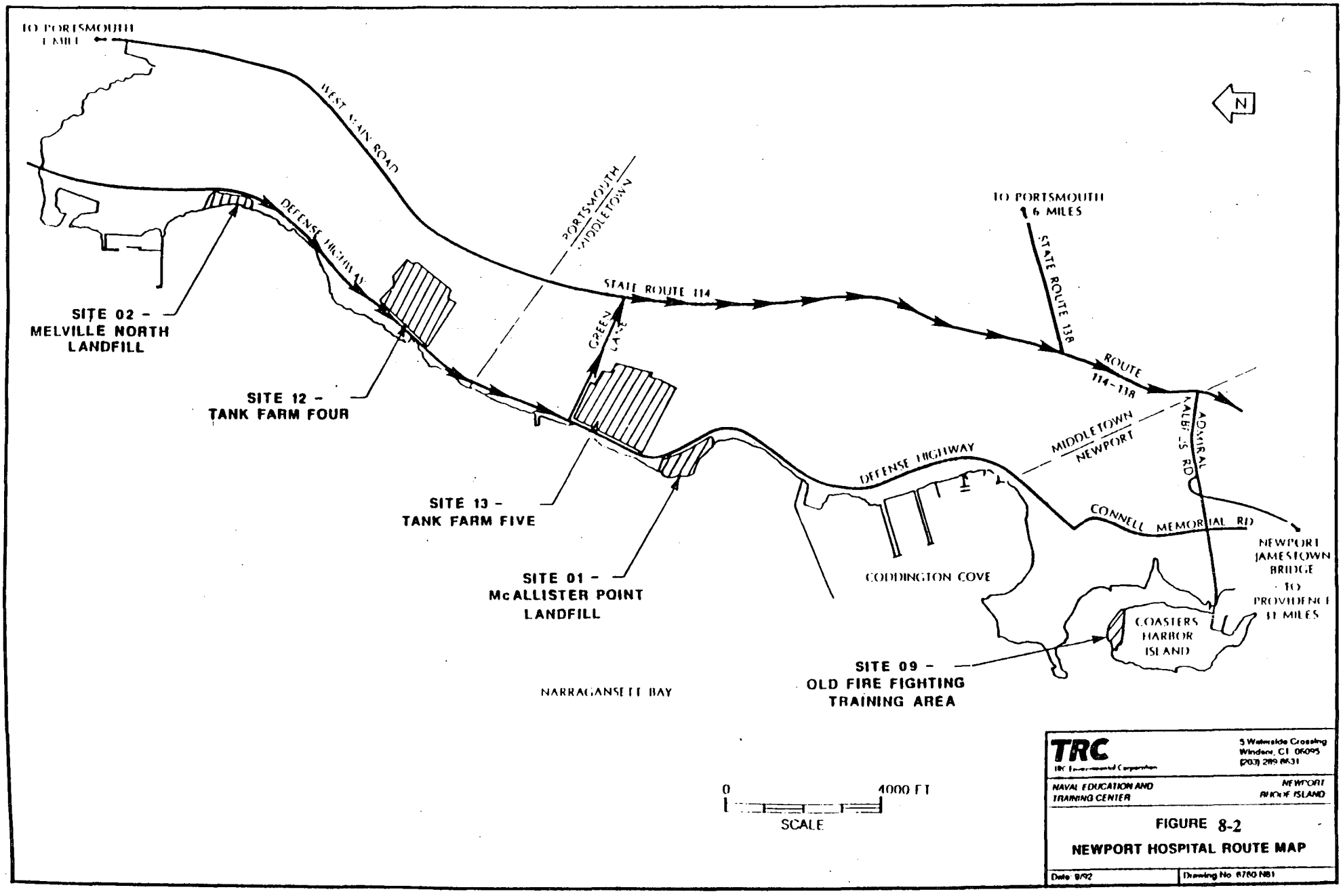
- Halliburton NUS Corporation
  187 Ballardvale Street
  Wilmington, MA. 01887

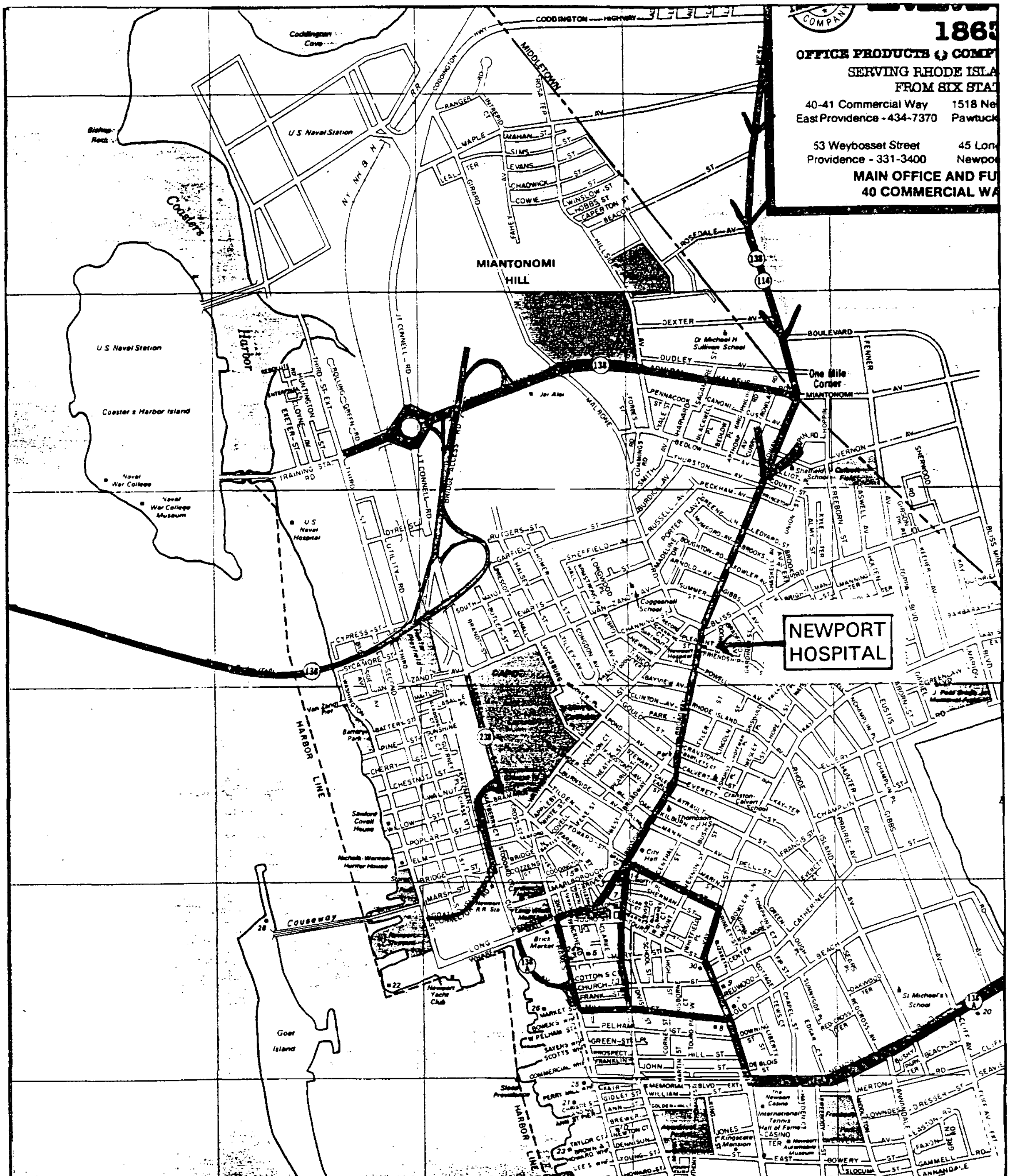
  Mr. Kevin Scully, Project Manager
  (508) 658-7899

FIGURE 8-1
EMERGENCY AND SITE PERSONNEL CONTACTS
PAGE THREE

- Halliburton NUS Corporation
  Foster Plaza 7, 661 Andersen Dr.
  Pittsburgh, Pennsylvania 15220-2745

  Ms. Debra A. Scheib, Program Quality Assurance Manager
  Mr. Matthew Soltis C.I.H, Health and Safety Officer
  (412) 921-7090


TO PORTSMOUTH
1 MILE
WEST MAIN ROAD
DEFENSE HIGHWAY
PORTSMOUTH
MIDDLETOWN
STATE ROUTE 114
GREEN LANE
TO PORTSMOUTH
6 MILES
STATE ROUTE 138
ROUTE
114-138
MIDDLETOWN
NEWPORT
ADMIRAL KALBFUS RD
DEFENSE HIGHWAY
CONNELL MEMORIAL RD
NEWPORT
JAMESTOWN
BRIDGE
TO
PROVIDENCE
11 MILES
CODDINGTON COVE
COASTERS
HARBOR
ISLAND
SITE 02 -
MELVILLE NORTH
LANDFILL
SITE 12 -
TANK FARM FOUR
SITE 13 -
TANK FARM FIVE
SITE 01 -
McALLISTER POINT
LANDFILL
SITE 09 -
OLD FIRE FIGHTING
TRAINING AREA
NARRAGANSETT BAY
N
0
4000 FT
SCALE
TRC
5 Waterside Crossing
Windsor, CT 06095
(203) 289 8631
NAVAL EDUCATION AND
TRAINING CENTER
NEWPORT
RHODE ISLAND
FIGURE 8-2
NEWPORT HOSPITAL ROUTE MAP
Date 9/92
Drawing No 6760 N81



NEWPORT HOSPITAL ROUTE MAP
MELVILLE NORTH LANDFILL SITE
NEWPORT, RHODE ISLAND

Halliburton NUS
CORPORATION

FIGURE 8-3

8.3 EMERGENCY RESPONSE PLAN - SPECIFIC INCIDENTS

8.3.1 Chemical Exposures

Inhalation

- If site personnel experience symptoms suggesting exposure to toxic chemicals (light-headed, dizziness, headache, nausea, shortness of breath or burning sensation in the mouth, throat or lungs), the person should be immediately escorted from the contaminated environment to fresh air.

- If unconscious, the victim should be removed from the contaminated area immediately and brought to the nearest hospital. Rescuers shall wear appropriate PPE during rescue.

- If the victim is no longer breathing, he/she shall be moved away from the contaminated area. Immediate mouth-to-mouth resuscitation or some alternate form of effective artificial respiration shall begin.

- If the victim has no pulse, he/she shall be moved away from the contaminated area and cardiopulmonary resuscitation (CPR) should begin immediately. It may be necessary for the victim to receive artificial resuscitation and CPR simultaneously.

Should any of the above scenarios be encountered, emergency medical attention/advice must be obtained immediately. The HNUS Project Manager should be notified of the situation and the affected individual(s) status as soon as practical.

Skin Exposure

If there is skin contact with toxic or potentially toxic chemicals, the skin should be washed with copious amounts of soap and water. If clothing is contaminated, it should be removed immediately and the skin washed thoroughly with running water. All contaminated parts of the body should be thoroughly washed. It may be necessary to wash repeatedly.

Ingestion

If site personnel ingest known toxic chemicals or suspected contaminated materials, obtain medical attention immediately.

Eye Exposure

If foreign matter should get into the eyes they should be flooded with water so that all surfaces are washed thoroughly. Washing should be continued for at least fifteen minutes. Medical attention should be obtained immediately.

8.3.2 Injury of Personnel

At a minimum, one person on site will be trained in Standard Red Cross First Aid. In the event of an emergency, this person will administer appropriate first aid and arrange transportation for injured personnel to the designated medical facility, if necessary. This person will evaluate the site conditions to determine if the causal hazard still exists. Site personnel shall not re-enter the Exclusion Zone until the cause of the injury is determined, and the Exclusion Zone is designated safe to re-enter.

8.3.3 Fire/Explosion

In the event of a fire or explosion, the SSO shall alert the NETC Fire Department by calling from a phone nearby the affected area. All personnel shall move to a safe distance from the involved area. The SSO shall make a determination regarding the severity of the fire, and whether site personnel shall attempt to extinguish it. Fires shall not be fought by site personnel if an explosion hazard is present or if a large fire is present on this site.

ATTACHMENT A

HEAT AND COLD STRESS

HEAT/COLD STRESS MONITORING

HEAT STRESS MONITORING

The heat stress monitoring program will be managed on-site by the SSO. Monitoring will based on heat stress monitoring.

Heat Stress Symptoms

Heat stroke is always life-threatening. The person's temperature control system that causes sweating stops working correctly. The body temperature rises so high that brain damage and death will result if the person is not cooled quickly. The main signs of heat stroke are red or flushed skin; hot, dry skin, although the person may have been sweating earlier; and extremely high body temperature, often to 41°C (106°F). There may be dizziness, nausea, headache, rapid pulse and unconsciousness.

Heat exhaustion is much less dangerous than heat stroke. The major signs of heat exhaustion are pale, clammy skin, profuse perspiration, and extreme tiredness or weakness. The body temperature is approximately normal. The person may have a headache and may vomit.

Cool a victim of heat stroke quickly. If the body temperature is not brought down fast, permanent brain damage or death may result. Soak the person in cool but not cold water, sponge the body with rubbing alcohol or cool water, or pour water on the body to reduce the temperature to a safe level, about 39°C (102°F). Then stop cooling and observe the victim for 10 minutes. Call an ambulance as soon as possible. If the temperature starts to rise again, cool the victim again. Do not give coffee, tea, or alcoholic beverages.

For mild heat exhaustion, stop work, remove the protective coveralls and get out of the sun. Give the person water, juice, or Gatorade. Medical care is needed for severe heat exhaustion.

Of particular importance is heat stress resulting when protective clothing decreases natural body ventilation. One or more of the following will help reduce heat stress:

1. Drinking water shall be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup, every 15-20 minutes (about 150 ml or 1/2 pint).

The water shall be kept reasonably cool (55-60°F) and shall be placed close to the work place so that the worker can reach it without abandoning the work area. However, where contaminants are known/suspected to exist that pose an ingestion toxicity hazard potential, workers shall not be permitted to consume any fluids without first being decontaminated and going to a noncontaminated area.

2. Long cotton underwear acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing. It should be the minimum undergarment worn.

3. When necessary/applicable, install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

4. In the extremely hot weather, conduct non-emergency response operations in the early morning or evening.

5. In hot weather, rotate shifts of workers wearing impervious clothing.

6. Good hygienic standards must be maintained by frequent changes of clothing and daily showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

7. Acclimatization to heat involves a series of physiological and psychological adjustments that occur in an individual during their first week of exposure to hot environmental conditions. The work-rest regimen in this procedure is valid for acclimated workers who are physically fit. Extra caution must be employed when unacclimated or physically unfit workers must be exposed to heat stress conditions.

8. Provide a shaded rest area.

Heat Stress Monitoring

In the event that heat stress/heat exhaustion is observed during work activities, the on-site HALLIBURTON NUS representative determines that the type of work may require careful monitoring, or environmental conditions dictate careful monitoring (e.g., respirators, plastic tyvek, and heavy workload) the following procedures could be implemented.

Work-Rest Regimen

Establishment of a proper work-rest regimen may be used in conjunction with the work load required to perform each task. Light work examples include sitting or standing to control machines or performing light hand or arm work. Moderate work includes walking about with moderate lifting and pushing or use of coated coveralls and respirators. Heavy work corresponds to pick and shovel-type work or the use of full body protective clothing. It must be assumed that any activity involving this type of clothing will be considered heavy work.

The work-rest regimen selected will be utilized as a baseline. The actual or adjusted period of work will be determined based on the biological monitoring outlined in the biological monitoring section.

Biological Monitoring

One of the following procedures shall be followed when the work-place temperature is 70°F or above, and/or upon this site HSO's discretion, in order to make sure the work/rest regime is providing proper personal protection and to document exposure.

1. Heart rate (HR) shall be measured by the pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/min. If the HR is higher, the next work period should be shortened by 10 minutes (or 33 percent), while the length of rest period stays the same. If the pulse rate is 100 beats/min at the beginning of the next rest period, the following work cycle should be shortened by 33 percent.

2. Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99°F. If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the OT exceeds 99.7°F at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The worker's OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with OT above 99°F.

HEAT STRESS PREVENTION WORK-REST REGIMENT GUIDELINES

(Values Are Given in 0°F WBGT)

Work Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous Work	86.0	80.0	77.0
75% Work - 25% Rest Each Hour	87.0	82.0	78.6
50% Work - 50% Rest Each Hour	89.0	85.0	82.0
25% Work - 75% Rest Each Hour	90.0	88.0	86.0

COLD STRESS MONITORING

Persons working outdoors in temperatures at or below freezing may experience frostbite. Extreme cold for a short time may cause severe injury to the surface of the body. Areas of the body that have a high surface area to volume ratio, such as fingers, toes, and ears, are the most susceptible.

Two factors influence the development of a cold injury: ambient temperature and the velocity of the wind. Wind chill (Table 1, HASP - Attachment A) is used to describe the chilling effect of moving air in combination with low temperature. For instance, 10°F with a wind of 15 mph is equivalent in chilling effect to still air at - 18°F.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed, if the clothing underneath is soaked with perspiration.

Frostbite

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

1. Frost nip or incident frostbite - the conditions are characterized by sudden blanching or whitening of skin.

2. Superficial frostbite - skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.

3. Deep frostbite - tissues are cold, pale, and solid; extremely serious injury.

Hypothermia

Authorities agree that there are degrees of hypothermia which are characterized as "moderate" and "severe". A victim of moderate hypothermia, who may exhibit the first seven signs listed below, is still conscious but often confused. Severe hypothermia is determined by extreme skin coldness; loss of consciousness; faint pulse; and shallow, infrequent, or apparently absent respiration. Death is the ultimate result.

Practically, the onset of severe shivering signals danger to personnel. Exposure to cold shall be immediately terminated for any severely shivering worker.

Signs of Hypothermia

1. Severe shivering
2. Abnormal behavior
3. Slowing
4. Stumbling
5. Weakness
6. Repeated falling
7. Inability to walk
8. Collapse
9. Stupor
10. Unconsciousness

Cold Stress Emergency Action

1. Remove the victim from the hypothermia-/frostbite-producing environment.

2. Seek expert medical help immediately.

3. Reduce handling to a minimum. Do not rub or massage the victim.

4. Prevent further body heat loss by covering the victim lightly with blankets. Plastic may be used for further insulation. Do not cover the victim's face.

5. If the victim is still conscious, administer hot drinks. Encourage activity, such as walking while wrapped in a blanket. Do not administer any form of sedative, tranquilizer, or analgesic (pain reliever), because these may facilitate further heat loss and convert moderate hypothermia into a severe case.

Cold Stress Work Place Monitoring

Work place monitoring is required as follows:

1. A thermometer accurate to 1°F shall be assigned at any work place where the environmental temperature is known or expected to be below 60°F to enable overall compliance with the requirements of this procedure.

2. Whenever the air temperature at a work place falls to 30°F or below, the dry-bulb temperature and wind speed shall be measured and recorded at least every 4 work-hours.

3. The equivalent chill temperature (ECT) shall be obtained (in all cases where air movement measurements are required) and shall be recorded with the other data in the site log, together with a record of the length of time spent working and resting.

Personal Protective Equipment Requirements for Cold Environments

Since prolonged exposure to cold air can lead to dangerous hypothermia, whole body protection must be provided as follows:

- Adequate insulating clothing, to maintain core temperatures above 97°F, must be provided to workers if work is performed in air temperatures below 40°F. Wind chill or the cooling power of the air is a critical factor.

  As wind speed increases and work area temperature decreases, the insulation values of the workers' protective clothing must increase. The equivalent chill temperature must be used when estimating the combined cooling effects of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature.

ATTACHMENT B

MSDS' AND HEALTH HAZARD INFORMATION

MATERIAL SAFETY DATA SHEET

GENIUM PUBLISHING CORPORATION
1145 CATALYN ST., SCHENECTADY, NY 12303 USA (518) 377-8854

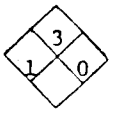
MSDS # G 354
METHYL ALCOHOL
Revision C
Issued:
Revised: September, 1985

From Genium's MSDS Collection, to be used as a reference.

SECTION 1. MATERIAL IDENTIFICATION

17

MATERIAL NAME: METHYL ALCOHOL
OTHER DESIGNATIONS: Methanol, Wood Alcohol, Carbinol, Wood Naphtha, Methyl Hydroxide, Monohydroxy Methane, CH_3OH, CAS #67-56-1
MANUFACTURER/SUPPLIER: Available from several suppliers, including; E.I. DuPont DeNemours & Co. (302- 774-2290
Chemicals & Pigments Dept (800) 441-9442
1007 Market St. Wilmington, DE 19898



SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	HAZARD DATA
METHYL ALCOHOL CH_3-OH	ca 100	8 hr TWA: 200 ppm, or 260 mg/m^3* (Skin) STEL: 250 ppm, or 310 mg/m^3 HUMAN Eye: 5 ppm, primary irritation dose Oral: LDLo: 340 mg/kg Inhalation: TCLo: 86,000 mg/m^3 - Toxic irritant effects (systemic)

* Current OSHA Standard; ACGIH (1985-86) TLV adds (skin) notation.

NIOSH has recommended a TWA standard of 200 ppm with a fifteen minute ceiling of 800 ppm. This ceiling is well above the TLV STEL of 250 ppm.

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm	148.5°F (64.7°C)	Viscosity @ 20°C, cps	0.59
Vapor density (Air=1)	1.11	Specific gravity, 20°/4°C	0.791
Vapor pressure @ 21°C, mmHg	100	Melting point	-144°F (-97.8°C)
@ 50°C, mmHg	400	Volatiles, %	ca 100
Water Solubility	Totally Miscible	Evaporation rate (BuAc=1)	5.9
		Molecular weight	32.04

APPEARANCE & ODOR: Clear, colorless, highly polar liquid with a characteristic alcohol odor. The odor recognition threshold (100% of test panel) is 53.3 ppm

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	Lower	Upper
60.8°F (12°C) Closed Cup	725°F (385°C)	% by Volume	6	36.5

EXTINGUISHING MEDIA: Use carbon dioxide, dry chemical, or alcohol type foam. Do not use a solid stream of water since the stream will scatter and spread the fire. Use water spray to cool fire-exposed tanks/containers. Fires involving Methyl Alcohol are Class IB; use a blanketing effect to smother fire.
Methyl Alcohol is a moderate explosion hazard and a dangerous fire hazard when exposed to heat, sparks, flame or oxidizers. Its vapors are heavier than air and may travel a considerable distance to an ignition source and flashback. Firefighters should wear self-contained breathing apparatus and full protective clothing when fighting fires involving Methyl Alcohol.

SECTION 5. REACTIVITY DATA

Methyl Alcohol is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization. This material may react violently with chromic anhydride; iodine plus ethyl alcohol, and mercuric oxide; lead perchlorate; perchloric acid plus ethyl alcohol; dimethyl formamide plus phosphorous; potassium hydroxide plus chlorioform; sodium hydroxide plus chloroform. It may also react with metallic aluminum at high temperatures.
Methyl Alcohol is incompatible with strong oxidizing agents (eg., nitrates, perchlorate or sulfuric acid), active metals, acetaldehyde, ethylene oxide, isocyanates, beryllium dihydride, chloroform, and potassium tert-butoxide. It may attack some forms of plastics and rubber. Thermal decomposition or burning will produce carbon monoxide, carbon dioxide and possible toxic formaldehyde and unburned methanol.

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SECTION 6. HEALTH HAZARD INFORMATION

TLV 200 ppm (skin) or 260 mg/m^3

Methanol is a poisonous, narcotic chemical that may exert its effects through inhalation, skin absorption, or ingestion. Elimination of Methanol from the body is slow, and the toxic effects can be compounded by repeated excessive exposures over several days. Toxic effects are exerted upon the CNS, especially the optic nerve and possibly the retinae. Symptoms of overexposure include dizziness, visual impairment, nausea, respiratory failure, muscular incoordination and narcosis. Visual disturbances may clear temporarily then re-occur and progress to blindness. Prolonged or repeated contact with the skin may cause dermatitis, erythema, and scaling. Vapors of Methanol are mildly irritating to the eyes, while direct contact with the liquid may cause irritation, pain and transient corneal opacity. Ingestion of Methanol can cause blindness and death. The fatal dose is 100-250 ml, although death from ingestion of less than 33 ml has been reported.
FIRST AID: EYE CONTACT: Immediately flush eyes, including under eyelids, with plenty of running water for at least 15 minutes. Get medical attention if irritation persists. SKIN CONTACT: Flush exposed area with water while removing contaminated clothing. Wash with soap and water. Get medical attention if irritation persists. INHALATION: Remove victim to fresh air. Restore and/or support breathing as needed. Get medical help (Inplant Paramedic, community). INGESTION: Give victim 3-4 glasses of water or milk and induce vomiting by sticking finger to back of throat. Contact a Poison Control Center or physician. Transport victim to a medical facility immediately. Do not induce vomiting or give anything to drink if victim is unconscious or having convulsions. Get medical attention (Inplant, paramedic, community).

SECTION 7. SPILL, LEAK AND DISPOSAL PROCEDURES

Notify safety personnel of large spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate all personnel from the area except for those involved in clean-up. Remove leaking container to safe place if feasible. Clean-up personnel should wear protective clothing, gloves, boots, and a self-contained breathing apparatus. Absorb small quantities on paper towel, vermiculite, or other absorbent and place in closed container for disposal. Dike large spills and collect for reclamation or disposal. Water spray may be used to knock down vapor and to dilute and flush spill away from sensitive areas. Do not flush to sewer. Keep out of watersheds and waterways.
DISPOSAL: Place in suitable container for disposal by a licensed contractor or burn in an approved incinerator. Waste solvent may be reclaimed via filtration and distillation procedures. Methyl Alcohol has been designated as a hazardous waste by the EPA (RCRA CFR 261.33). The EPA Hazardous Waste No. is U154. Aquatic Toxicity Rating: TLm96: Over 1000 ppm.

SECTION 8. SPECIAL PROTECTION INFORMATION

Provide general and local exhaust ventilation (explosion-proof) to meet TLV requirements. For emergency or non-routine exposures where the TLV may be exceeded, wear an appropriate NIOSH-approved respirator. All electrical service in use or storage areas should have an explosion-proof design.
Prevent skin and eye contact by wearing rubber gloves and splash goggles or safety glasses. Use protective aprons, boots and face shield as necessary when splashing may occur.
Eyewash stations and safety showers should be available in areas of use and handling. Provide suitable training to those working with Methanol. Monitor the workplace and keep accurate records.

Contact lenses pose a special hazard; soft lenses may absorb and all lenses concentrate irritants.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store in tightly closed containers in a dry, well-ventilated area away from strong oxidizing agents, heat, sparks and open flame. Protect container from physical damage. When transferring or pouring Methyl Alcohol, ground and bond containers and equipment to prevent static sparks. Use non-sparking tools.
Do not smoke in areas of use or storage. Use with adequate ventilation. Do not breathe vapors. Avoid contact with eyes and skin. This material is poisonous when introduced into the body metabolism. DO NOT INGEST!!!
Provide preplacement medical exams and periodic medical surveillance for industrially exposed workers with emphasis on neurological and visual functions, liver, and kidney systems.
DOT CLASSIFICATION: Flammable liquid, UN1230 DOT LABEL: Flammable liquid.

DATA SOURCE(S) CODE (See Glossary) 1, 2, 4-12, 16, 19, 20, 23-26, 31, 34, 37-39, 43, 47, 63, 79. R.

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APPROVALS JO Accrocco, 11/85
INDUST. HYGIENE/SAFETY [signature] 11-85
MEDICAL REVIEW: [signature] Dec 85

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Material Safety Data Sheet

Required under USDL Safety and Health Regulations for Shipyard Employment (29 CFR 1915)

ALCONOX POWDER DETERGENT

U.S. Department of Labor

Occupational Safety and Health Administration

04-322-4

OMB No. 1218-0074
Expiration Date 05/31/86

PREPARED 1/2/85

Section I

Manufacturer's Name: ALCONOX, INC.

Emergency Telephone Number: (212) 473-1300

Address (Number, Street, City, State, and ZIP Code): 215 PARK AVENUE SOUTH

NEW YORK, N.Y. 10003

Chemical Name and Synonyms: N.A.

Trade Name and Synonyms: ALCONOX

Chemical Family: ANIONIC DETERGENT

Formula: N.A.

Section II - Hazardous Ingredients

Paints, Preservatives, and Solvents	%	TLV (Units)	Alloys and Metallic Coatings	%	TLV (Units)
Pigments: NONE			Base Metal: NONE		
Catalyst: NONE			Alloys: NONE		
Vehicle: NONE			Metallic Coatings: NONE		
Solvents: NONE			Filler Metal Plus Coating or Core Flux: NONE		
Additives: NONE			Others: NONE		
Others: NONE					

Hazardous Mixtures of Other Liquids, Solids or Gases

	%	TLV (Units)
NONE		

RECEIVED AUG 1985

Section III - Physical Data

Boiling Point (°F)	N.A.	Specific Gravity (H_2O=1)	N.A.
Vapor Pressure (mm Hg.)	N.A.	Percent Volatile by Volume (%)	N.A.
Vapor Density (AIR=1)	N.A.	Evaporation Rate (_____=1)	N.A.

Solubility in Water: APPRECIABLE

Appearance and Odor: WHITE POWDER INTERSPERSED WITH CREAM COLORED FLAKES - ODORLESS

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used): NONE

Flammable Limits: N.A. Lel: N.A. Uel: N.A.

Extinguishing Media: WATER, CO_2, DRY CHEMICAL, FOAM, SAND/EARTH

Special Fire Fighting Procedures: FOR FIRES INVOLVING THIS MATERIAL, DO NOT ENTER WITHOUT PROTECTIVE EQUIPMENT AND SELF CONTAINED BREATHING APPARATUS

Unusual Fire and Explosion Hazards: NONE

Section V - Health Hazard Data

ALCOXOX POWDER
04-322-4
04-322-5B, 5C & 5D

Threshold Limit Value

NO DATA AVAILABLE - TREAT AS NUISANCE DUST

Effects of Overexposure

PROLONGED EXPOSURE TO DUST MAY IRRITATE MUCOUS MEMBRANES

Emergency First Aid Procedures

EYES - FLUSH WITH PLENTY OF WATER FOR 15 MINUTES. SKIN-FLUSH WITH PLENTY OF WATER. INGESTION - DRINK LARGE QUANTITIES OF WATER TO DILUTE MATERIAL. GET MEDICAL ATTENTION FOR DISCOMFORT.

Section VI - Reactivity Data

Stability	Unstable		Conditions to Avoid: NONE
	Stable: X		

Incompatability (Materials to Avoid): AVOID STRONG ACIDS

Hazardous Decomposition Products: MAY RELEASE CO_2 GAS ON BURNING

Hazardous Polymerization	May Occur		Conditions to Avoid: NONE
	Will Not Occur: X		

Section VII - Spill or Leak Procedures

Steps to be Taken in Case Material is Released or Spilled

MATERIAL FOAMS PROFUSELY. SHOVEL AND RECOVER AS MUCH AS POSSIBLE. RINSE REMAINDER TO SEWER. MATERIAL IS COMPLETELY BIODEGRADABLE.

Waste Disposal Method

SMALL QUANTITIES MAY BE DISPOSED OF IN SEWER. LARGE QUANTITIES SHOULD BE DISPOSED OF ACCORDING TO LOCAL REQUIREMENTS FOR NON-HAZARDOUS DETERGENT

Section VIII - Special Protection Information

Respiratory Protection (Specify Type): DUST MASK

Ventilation	Local Exhaust	NORMAL	Special	N.A.
	Mechanical (General)	N.A.	Other	N.A.

Protective Gloves: USEFUL - NOT REQUIRED	Eye Protection: USEFUL - NOT REQUIRED

Other Protective Equipment: NOT REQUIRED

Section IX - Special Precautions

Precautions to be Taken in Handling and Storing

SHOULD BE STORED IN A DRY AREA TO PREVENT CAKING

Other Precautions

NO SPECIAL REQUIREMENTS OTHER THAN THE GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES EMPLOYED WITH ANY INDUSTRIAL CHEMICAL.

Material Safety Data Sheet

From Genium's Reference Collection
Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP.

No. 7

NITRIC ACID
(Revision C)
Issued: October 1980
Revised: August 1988

SECTION 1. MATERIAL IDENTIFICATION

26

Material Name: NITRIC ACID

Description (Origin/Uses): Used to dissolve noble metals, for etching and cleaning metals, to make organic nitrates and nitrocompounds, to destroy residues of organic matter, and in explosives.

Other Designations: Red Fuming Nitric Acid; HNO_3; CAS No. 7697-37-2

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

NFPA: 0 / 3 / 0 / oxy

HMIS			
H	3	R	1
F	0	I	4
R	1	S	4
PPG*		K	0

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

Ingredients and Hazards	%	Exposure Limits
Nitric Acid, CAS No. 7697-37-2	*	**OSHA PEL** 8-Hr TWA: 2 ppm, 5 mg/m³ **ACGIH TLVs, 1987-88** TLV-TWA: 2 ppm, 5 mg/m³ TLV-STEL: 4 ppm, 10 mg/m³ **Toxicity Data**** Mouse, Inhalation, LC_{50}: 67 ppm/4 Hrs

*Contact your supplier to determine the percent by weight of nitric acid in the purchased product. Water is the other component of the product.
**See NIOSH, *RTECS* (QU5775000, QU5900000), for additional data with references to reproductive effects.

SECTION 3. PHYSICAL DATA

Boiling Point: Ca 251°F (122°C)*
Specific Gravity (H_2O = 1): 1.4*
pH: Very Acidic

Water Solubility (%): Complete
Molecular Weight: 63 Grams/Mole
Melting Point: Ca -30°F (-34°C)*

Appearance and Odor: A water white to slightly yellow liquid that darkens to a brownish color on aging and exposure to light; characteristic nitrogen dioxide (NO_2) odor.

*These properties are for the approximately 68%-by-weight nitric acid that is commercially available.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air % by Volume	LOWER	UPPER
*	*		*	*

Extinguishing Media: *Nitric acid does not burn. Use extinguishing agents that will put out the surrounding fire. Use a water spray to dilute nitric acid during fires and to absorb liberated oxides of nitrogen.

Unusual Fire or Explosion Hazards: Although nitric acid does not burn, it is a strong oxidizing agent that can react with combustible materials to cause fires. Also, it can react with metals to liberate extremely flammable hydrogen gas. If this happens, direct fire-fighting procedures at this evolved hydrogen gas.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Choose protective equipment carefully (see sect. 5, Conditions to Avoid).

SECTION 5. REACTIVITY DATA

Nitric acid is stable in closed containers at room temperature under normal storage and handling conditions. It cannot undergo hazardous polymerization.

Chemical Incompatibilities: Nitric acid reacts explosively with metallic powders, carbides, hydrogen sulfide, and turpentine. Contact with organic materials such as wood, paper, sawdust, or alcohol, etc., may cause fires. Combustible materials can attain an increased flammability after being exposed to nitric acid even if they do not immediately catch fire.

Conditions to Avoid: Avoid any contact with incompatible chemicals. Because it is so reactive, always establish another material's compatibility with nitric acid before mixing the two materials. This applies to the selection of safety and handling equipment, because nitric acid can attack some forms of coatings, plastics, and rubber.

Hazardous Products of Decomposition: Various nitrogen oxides, including nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide (N_2O), as well as nitric acid mist or vapor, can be produced by the decomposition reactions that can affect the nitric acid during fires.

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SECTION 6. HEALTH HAZARD INFORMATION

Nitric acid is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: This material is corrosive to any body tissue it contacts. Dental erosion is also reported.
Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** Skin, eyes, mucous membranes of the respiratory tract, teeth. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** Irritation and/or corrosive burns of skin, eyes, and upper respiratory tract (URT), delayed pulmonary edema, pneumonitis, bronchitis, and dental erosion. **Chronic Effects:** None reported.

FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Treat for eye burns. **Skin.** Immediately wash the affected area with soap and water. Watch for chemical skin burns and treat them accordingly. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. If the exposure is severe, hospitilization with careful monitoring by trained medical personnel to detect the delayed onset of severe pulmonary edema (lungs filled with fluid) is recommended for at least 72 hours. **Ingestion.** Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. Do not induce vomiting. If the exposed person is responsive, give him or her one or two glasses of milk or water to drink as quickly as possible after exposure.
GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid. NOTE TO PHYSICIAN: Wash affected skin areas with a 5% solution of sodium bicarbonate ($NaHCO_3$). If ingested, the risk versus the benefit of the passage of a naso-gastric tube is debatable. Activated charcoal is of *no* value. Do *not* give the exposed person bicarbonate to neutralize the material.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, provide ventilation, and eliminate all sources of ignition immediately in case contact with metals should produce highly flammable hydrogen gas. Cleanup personnel need protection against contact with and inhalation of nitric acid (see sect. 8). Contain large spills and collect waste. Use water sprays to direct nitric acid away from incompatible chemicals (see sect. 5). Neutralize the spilled nitric acid with soda ash or sodium bicarbonate. Use an absorbent such as sand, earth, or vermiculite on the resulting slurry and place the neutralized nitric acid material into containers suitable for eventual disposal, reclamation, or destruction.
Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.
OSHA Designations
Air Contaminant (29 CFR 1910.1000 Subpart Z)
EPA Designations (40 CFR 302.4)
CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg), per Clean Water Act (CWA), Section 311 (b) (4)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of nitric acid solution is possible, wear a full face shield as a supplementary protective measure. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Consult the *NIOSH Pocket Guide to Chemical Hazards* (Genium ref. 88) for general recommendations on proper respiratory procedures. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine use (leaks or cleaning reactor vessels and storage tanks), wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with nitric acid. Choose protective equipment carefully (see sect. 5, Conditions to Avoid).
Ventilation: Install and operate both general and local exhaust-ventilation systems powerful enough to maintain airborne concentrations of nitric acid below the OSHA PEL standard cited in section 2. Construct exhaust ducts and systems with material such as fiberglass, which resists attack by nitric acid. **Safety Stations:** Make emergency eyewash stations, washing facilities, and safety/quickdrench showers available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean nitric acid from shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Provide preplacement and annual medical exams with emphasis on skin irritation to workers who are regularly exposed to nitric acid. Workers must receive training before handling this material in the workplace; even experienced workers should undergo refresher training periodically.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store nitric acid in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). Consider outside, isolated, or detached storage. Protect containers from direct sunlight.
Special Handling/Storage: Build all storage facilities of nonflammable materials that are resistant to chemical attack by nitric acid. Protect containers from physical damage. Preplan for routine use and emergency response.
Engineering Controls: Proper ventilation is essential in bulk storage areas; consider installing an automatic monitoring system to detect hazardous levels of nitrogen oxides that can develop from this material.
Comments: Separate nitric acid from hydrazine, diethylenetriamine, fluorides, and all other corrosives except sulfuric acid and sulfur trioxide when shipping or transferring it.
Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: (I) Nitric Acid, Fuming or (II) Nitric Acid, Over 40% or (III) Nitric Acid, 40% or Less
DOT Label: (I) Oxidizer and Poison or (II) Oxidizer and Corrosive or (III) Corrosive
DOT Hazard Class: (I) and (II) Oxidizer or (III) Corrosive Material
DOT ID Nos. (I) UN2032; (II) UN2031; (III) NA1760
IMO Class: 8 (All Types of Nitric Acid)
IMO Label: (I) Corrosive, Oxidizer, Poison; or (II) and (III) Corrosive
References: 1, 2, 26, 38, 84-94, 100, 112, 113, 114.

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**HYDROCHLORIC ACID, CONCENTRATED (36-37
**HYDROCHLORIC ACID, CONCENTRATED (36-37
**HYDROCHLORIC ACID, CONCENTRATED (36-37

MATERIAL SAFETY DATA SHEET

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CHEMICAL DIVISION
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EMERGENCY NUMBER: (201) 796-7100
CHEMTREC ASSISTANCE: (800) 424-9300

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SUBSTANCE IDENTIFICATION

CAS-NUMBER 7647-01-0

SUBSTANCE: **HYDROCHLORIC ACID, CONCENTRATED (36-37%)**

TRADE NAMES/SYNONYMS:
CHLORDHYDRIC ACID; HYDROCHLORIDE; MURIATIC ACID; SPIRITS OF SALT; HYDROCHLORIC ACID, CONCENTRATED; HYDROGEN CHLORIDE, 23 EB; UN 1789; A-142; A-144; A-508; A-466;

CHEMICAL FAMILY:
INORGANIC ACID

MOLECULAR FORMULA: H-CL

MOLECULAR WEIGHT: 36.46

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=1 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: HYDROGEN CHLORIDE PERCENT: 37

COMPONENT: WATER PERCENT: 63

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
5 PPM OSHA CEILING
5 PPM ACGIH CEILING

500 POUNDS SARA SECTION 302 THRESHOLD PLANNING QUANTITY (GAS)
5000 POUND SARA SECTION 304 REPORTABLE QUANTITY (GAS)
5000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY (LIQUID)
SUBJECT TO SARA SECTION 313 ANNUAL TOXIC CHEMICAL RELEASE REPORTING

PHYSICAL DATA

DESCRIPTION: COLORLESS OR SLIGHTLY YELLOW FUMING LIQUID WITH A PUNGENT ODOR. BOILING POINT: 384 F (196 C) SPECIFIC GRAVITY: 1.2

VAPOR PRESSURE: NOT AVAILABLE PH: 1.1 (0.1 N)

SOLUBILITY IN WATER: SOLUBLE VAPOR DENSITY: 1.3

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY OR REGULAR FOAM
(1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR REGULAR FOAM
(1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FIREFIGHTING:
MOVE CONTAINER FROM FIRE AREA IF YOU CAN DO IT WITHOUT RISK. APPLY COOLING WATER TO SIDES OF CONTAINERS THAT ARE EXPOSED TO FLAMES UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM ENDS OF TANKS (1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5, GUIDE PAGE 60).

EXTINGUISH USING AGENTS SUITABLE FOR TYPE OF FIRE. USE FLOODING AMOUNTS OF WATER AS FOG. COOL CONTAINERS WITH FLOODING AMOUNTS OF WATER, APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING CORROSIVE VAPORS, KEEP UPWIND.

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49 CFR 172.101:
CORROSIVE MATERIAL

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49 CFR 172.101 AND SUBPART E:
CORROSIVE

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49 CFR 173.263
EXCEPTIONS: 49 CFR 173.244.

TOXICITY

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
IRRITATION DATA:
ANHYDROUS: 100 MG RINSED EYE-RABBIT MILD.
HYDROCHLORIC ACID: 5 MG/30 SECONDS RINSED EYE-RABBIT MILD.
TOXICITY DATA:
HYDROGEN CHLORIDE (ANHYDROUS GAS): 4701 PPM/30 MINUTES INHALATION-RAT LC50;

2644 PPM/30 MINUTES INHALATION-MOUSE LC50.
MONOHYDRATE: NO DATA AVAILABLE.
DIHYDRATE: NO DATA AVAILABLE.
TRIHYDRATE: NO DATA AVAILABLE.
HEXAHYDRATE: NO DATA AVAILABLE.
HYDROGEN CHLORIDE (AEROSOL): 5666 PPM/30 MINUTES INHALATION-RAT LC50; 2142 PPM/30 MINUTES INHALATION-MOUSE LC50.
HYDROCHLORIC ACID: 1300 PPM/30 MINUTES INHALATION-HUMAN LCLO; 3000 PPM/5 MINUTES INHALATION-HUMAN LCLO; 81 MG/KG UNREPORTED MAN LDLO; 3124 PPM/1 HOUR INHALATION-RAT LC50; 1108 PPM/1 HOUR INHALATION-MOUSE LC50; 1449 MG/KG INTRAPERITONEAL-MOUSE LD50; 900 MG/KG ORAL-RABBIT LD50; 4416 PPM/30 MINUTES INHALATION-RABBIT LCLO; 4416 PPM/30 MINUTES INHALATION-GUINEA PIG LCLO; 1000 MG/M3/2 HOURS INHALATION-MAMMAL LCLO; MUTAGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS).
CARCINOGEN STATUS: NONE.
LOCAL EFFECTS: CORROSIVE- INHALATION, SKIN, EYE AND INGESTION.
ACUTE TOXICITY LEVEL: MODERATELY TOXIC BY INHALATION, INGESTION.
TARGET EFFECTS: NO DATA AVAILABLE.

HEALTH EFFECTS AND FIRST AID

INHALATION:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
CORROSIVE. 100 PPM IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.
ACUTE EXPOSURE- INHALATION OF GAS OR FUMES AT LEVELS OF 5-35 PPM MAY CAUSE IRRITATION AND BURNING OF THE THROAT, COUGHING AND CHOKING; 50-100 PPM MAY BE BARELY TOLERABLE FOR 1 HOUR. HIGH LEVELS MAY CAUSE INFLAMMATION AND OCCASIONALLY ULCERATION OF THE NOSE, THROAT OR LARYNX, BRONCHITIS, PNEUMONIA, PALPITATIONS AND HEADACHE. HIGHER CONCENTRATIONS MAY CAUSE NECROSIS OF THE TRACHEAL AND BRONCHIAL EPITHELIUM, NASOSEPTAL PERFORATION, ATELECTASIS, EMPHYSEMA, DAMAGE TO PULMONARY BLOOD VESSELS AND LESIONS OF THE LIVER AND OTHER ORGANS. DEATH MAY BE DUE TO LARYNGEAL SPASM, BRONCHOPNEUMONIA OR PULMONARY EDEMA. 1300-2000 PPM MAY BE DANGEROUS, EVEN ON BRIEF EXPOSURES. REPRODUCTIVE EFFECTS HAVE BEEN REPORTED IN ANIMALS.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE EROSION AND DISCOLORATION OF EXPOSED TEETH, CHRONIC BRONCHITIS AND GASTRITIS.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
CORROSIVE.
ACUTE EXPOSURE- CONTACT MAY CAUSE SEVERE IRRITATION, INFLAMMATION, ULCERATION, NECROSIS AND CHEMICAL BURNS. SHOCK SYMPTOMS MAY DEVELOP INCLUDING RAPID PULSE, SWEATING AND COLLAPSE. PHOTOSENSITIZATION REACTIONS MAY OCCUR IN PERSONS PREVIOUSLY EXPOSED. CONTACT WITH A COMPRESSED GAS MAY CAUSE FROSTBITE.
CHRONIC EXPOSURE- REPEATED OR PROLONGED CONTACT WITH VAPORS OR DILUTE SOLUTIONS MAY CAUSE DERMATITIS. PHOTOSENSITIZATION MAY OCCUR.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). IN CASE OF CHEMICAL BURNS, COVER AREA WITH STERILE, DRY DRESSING. BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
CORROSIVE.
ACUTE EXPOSURE- CONTACT MAY CAUSE SEVERE IRRITATION, CONJUNCTIVITIS, CORNEAL NECROSIS AND BURNS WITH IMPAIRMENT OR PERMANENT LOSS OF VISION. A DROP OF HYDROCHLORIC ACID SPLASHED IN THE EYE AND IMMEDIATELY WASHED OUT HAS PRODUCED A WHITE COAGULATION OF THE CORNEAL AND CONJUNCTIVAL EPITHELIUM. ANIMALS EXPOSED TO VAPOR CONCENTRATIONS OF 1350 PPM FOR ONE AND A HALF HOURS SHOWED CLOUDING OF THE CORNEA AND 300 PPM FOR 6 HOURS SHOWED SLIGHT EROSION OF THE CORNEAL EPITHELIUM. CONTACT WITH A COMPRESSED GAS MAY CAUSE FROSTBITE.
CHRONIC EXPOSURE- ANIMALS EXPOSED TO VAPOR AT 100 PPM FOR 6 HOURS DAILY FOR 50 DAYS SHOWED ONLY SLIGHT UNREST AND IRRITATION OF THE EYES, BUT NO OCULAR INJURY. EFFECTS ARE DEPENDENT UPON CONCENTRATION AND DURATION OF EXPOSURE. CONJUNCTIVITIS OR EFFECTS SIMILAR TO THOSE FOR ACUTE EXPOSURE MAY OCCUR.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-60 MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
CORROSIVE.
ACUTE EXPOSURE- INGESTION OF THE ACID MAY CAUSE BURNS OF THE MOUTH, THROAT, ESOPHAGUS AND STOMACH WITH CONSEQUENT PAIN, UNEASINESS, NAUSEA, SALIVATION, VOMITING, DIARRHEA, CHILLS, SHOCK AND INTENSE THIRST. NEPHRITIS, FEVER AND PERFORATION OF THE INTESTINAL TRACT, AND CIRCULATORY COLLAPSE MAY OCCUR. DEATH MAY BE DUE TO ESOPHAGEAL OR GASTRIC NECROSIS.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- DO NOT USE GASTRIC LAVAGE OR EMESIS. DILUTE THE ACID IMMEDIATELY BY DRINKING LARGE QUANTITIES OF WATER OR MILK. IF VOMITING PERSISTS, ADMINISTER FLUIDS REPEATEDLY. INGESTED ACID MUST BE DILUTED APPROXIMATELY 100 FOLD TO RENDER IT HARMLESS TO TISSUES. MAINTAIN AIRWAY AND TREAT SHOCK (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD BELOW HIPS TO HELP PREVENT ASPIRATION.

ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
REACTS EXOTHERMICALLY WITH WATER OR STEAM TO PRODUCE TOXIC AND CORROSIVE FUMES.

CONTACT WITH COMMON METALS PRODUCES HYDROGEN WHICH MAY FORM EXPLOSIVE

MIXTURES WITH AIR.

INCOMPATIBILITIES:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
ACETIC ANHYDRIDE: VIOLENT REACTION.
ALCOHOLIC HYDROGEN CYANIDE: EXPLOSIVE REACTION.
ALUMINUM: EXPLOSION.
ALUMINUM-TITANIUM ALLOYS: IGNITES OR INCANDESCES WHEN HEATED.
2-AMINOETHANOL: VIOLENT REACTION.
AMMONIUM HYDROXIDE: VIOLENT REACTION.
BASES: VIOLENT REACTION.
BRASS: CORRODES.
BRONZE: CORRODES.
CALCIUM CARBIDE: REACTS WITH INCANDESCENCE.
CALCIUM HYPOCHLORITE: IGNITION.
CESIUM ACETYLIDE: IGNITES ON CONTACT.
CHLORINE + DINITROANILINES: VIGOROUS REACTION WITH RELEASE OF FLAMMABLE HYDROGEN GAS FUMES.
CHLOROSULFONIC ACID: VIOLENT REACTION.
1,1-DIFLUOROETHYLENE: EXTREMELY EXOTHERMIC DECOMPOSITION REACTION.
DOWICIL 100: DECOMPOSES.
ETHYLENE DIAMINE: VIOLENT REACTION.
ETHYLENE IMINE: VIOLENT REACTION.
FLUORINE: IGNITES ON CONTACT.
HEXALITHIUM DISILICIDE: INCANDESCES.
IRON: CORRODES WITH EVOLUTION OF FLAMMABLE HYDROGEN GAS.
MAGNESIUM BORIDE: PRODUCES A SPONTANEOUSLY FLAMMABLE GAS.
MERCURIC SULFATE: VIOLENT REACTION AT 125 C.
METAL ACETYLIDES: VIOLENT REACTION.
METALS: SEVERE CORROSION WITH EVOLUTION OF FLAMMABLE HYDROGEN GAS.
OLEUM: VIOLENT REACTION.
OXIDIZERS (STRONG): VIOLENT REACTION.
OXYGEN + PLATINUM: IGNITES ON CONTACT.
PERCHLORIC ACID: VIOLENT REACTION.
PLASTICS, RUBBER, COATINGS: ATTACKS.
POTASSIUM PERMANGANATE: EXPLOSION HAZARD.
BETA-PROPIOLACTONE: VIOLENT REACTION.
PROPYLENE OXIDE: VIOLENT REACTION.
RUBIDIUM ACETYLIDE: IGNITES ON CONTACT.
SILICA (GEL): INCOMPATIBLE.
SODIUM: VIGOROUS OR EXPLOSIVE REACTION.
SULFURIC ACID: EXPLOSIVE REACTION WITH RELEASE OF TOXIC HYDROGEN CHLORIDE GAS.
TETRASELENIUM TETRANITRIDE: EXPLODES ON CONTACT.
VINYL ACETATE: VIOLENT REACTION.

DECOMPOSITION:
THERMAL DECOMPOSITION MAY RELEASE CORROSIVE HYDROGEN CHLORIDE.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE AND DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE

ENVIRONMENTAL PROTECTION AGENCY.

STORAGE

THRESHOLD PLANNING QUANTITY (TPQ):
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 302 REQUIRES THAT EACH FACILITY WHERE ANY EXTREMELY HAZARDOUS SUBSTANCE IS PRESENT IN A QUANTITY EQUAL TO OR GREATER THAN THE TPQ ESTABLISHED FOR THAT SUBSTANCE NOTIFY THE STATE EMERGENCY RESPONSE COMMISSION FOR THE STATE IN WHICH IT IS LOCATED. SECTION 303 OF SARA REQUIRES THESE FACILITIES TO PARTICIPATE IN LOCAL EMERGENCY RESPONSE PLANNING (40 CFR 355.30).

PROTECT AGAINST PHYSICAL DAMAGE. STORE IN COOL, WELL-VENTILATED PLACE, SEPARATED FROM ALL OXIDIZING MATERIALS (NFPA 49, HAZARDOUS CHEMICALS DATA, 1975).

****
CONDITIONS TO AVOID

MAY BURN BUT DOES NOT IGNITE READILY. FLAMMABLE, POISONOUS GASES MAY ACCUMULATE IN TANKS AND HOPPER CARS. MAY IGNITE COMBUSTIBLES (WOOD, PAPER, OIL, ETC.).

****
SPILL AND LEAK PROCEDURES

SOIL SPILL:
DIG HOLDING AREA SUCH AS LAGOON, POND OR PIT FOR CONTAINMENT.

DIKE FLOW OF SPILLED MATERIAL USING SOIL OR SANDBAGS OR FOAMED BARRIERS SUCH AS POLYURETHANE OR CONCRETE.

USE CEMENT POWDER OR FLY ASH TO ABSORB LIQUID MASS.

NEUTRALIZE SPILL WITH SLAKED LIME, SODIUM BICARBONATE OR CRUSHED LIMESTONE.

AIR SPILL:
KNOCK DOWN VAPORS WITH WATER SPRAY. KEEP UPWIND.

WATER USED TO KNOCK DOWN VAPORS MAY BECOME CORROSIVE OR TOXIC AND SHOULD BE CONTAINED PROPERLY FOR LATER DISPOSAL.

WATER SPILL:
NEUTRALIZE WITH AGRICULTURAL LIME, SLAKED LIME, CRUSHED LIMESTONE, OR SODIUM BICARBONATE.

OCCUPATIONAL SPILL:
DO NOT TOUCH SPILLED MATERIAL. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR SMALL DRY SPILLS, WITH CLEAN SHOVEL PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND COVER. MOVE CONTAINERS FROM SPILL AREA. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. KEEP UNNECESSARY PEOPLE AWAY. ISOLATE HAZARD AREA AND DENY ENTRY.

REPORTABLE QUANTITY (RQ): 1 POUND
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES

THAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS SUBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE AND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF THIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE CENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE METROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST OR PROCESS ENCLOSURE VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS.

RESPIRATOR:
THE FOLLOWING RESPIRATORS ARE RECOMMENDED BASED ON INFORMATION FOUND IN THE PHYSICAL DATA, TOXICITY AND HEALTH EFFECTS SECTIONS. THEY ARE RANKED IN ORDER FROM MINIMUM TO MAXIMUM RESPIRATORY PROTECTION.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST BE BASED ON THE SPECIFIC OPERATION, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND MUST BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION (NIOSH-MSHA).

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

50 PPM- ANY SUPPLIED-AIR RESPIRATOR.
ANY SELF-CONTAINED BREATHING APPARATUS.
ANY CHEMICAL CARTRIDGE RESPIRATOR WITH CARTRIDGE(S) PROVIDING PROTECTION AGAINST HYDROCHLORIC ACID.
ANY POWERED AIR-PURIFYING RESPIRATOR WITH CARTRIDGE(S) PROVIDING PROTECTION AGAINST HYDROCHLORIC ACID.

100 PPM- ANY SUPPLIED-AIR RESPIRATOR OPERATED IN A CONTINUOUS FLOW MODE.
ANY SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE.
ANY SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.

ESCAPE- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONT- OR BACK-MOUNTED ACID GAS CANISTER.
ANY APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

ANY SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

ANY SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES AND A FACESHIELD TO PREVENT CONTACT WITH THIS SUBSTANCE.

EMERGENCY WASH FACILITIES:
WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES AND/OR SKIN MAY BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH FOUNTAIN AND QUICK DRENCH SHOWER WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - FISHER SCIENTIFIC, INC.
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BENZENE

BNZ

Common Synonyms
Benzol
Benzole

Watery liquid — Colorless — Gasoline-like odor

Floats on water. Flammable, irritating vapor is produced. Freezing point is 42°F.

Avoid contact with liquid and vapor. Keep people away.
Wear goggles and self-contained breathing apparatus.
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-high flammability
Restrict access

2. LABEL

2.1 **Category:** Flammable liquid
2.2 **Class:** 3

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Aromatic Hydrocarbon
3.2 **Formula:** C_6H_6
3.3 **IMO/UN Designation:** 3.2/1114
3.4 **DOT ID No.:** 1114
3.5 **CAS Registry No.:** 71-43-2

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Aromatic; rather pleasant aromatic odor; characteristic odor

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Hydrocarbon vapor canister, supplied air or a hose mask; hydrocarbon-insoluble rubber or plastic gloves; chemical goggles or face splash shield; hydrocarbon-insoluble apron such as neoprene.
5.2 **Symptoms Following Exposure:** Dizziness, excitation, pallor, followed by flushing, weakness, headache, breathlessness, chest constriction. Coma and possible death.
5.3 **Treatment of Exposure:** SKIN: Flush with water followed by soap and water; remove contaminated clothing and wash skin. EYES: flush with plenty of water until irritation subsides. INHALATION: remove from exposure immediately. Call a physician. IF breathing is irregular or stopped, start resuscitation, administer oxygen.
5.4 **Threshold Limit Value:** 10 ppm
5.5 **Short Term Inhalation Limits:** 75 ppm for 30 min.
5.6 **Toxicity by Ingestion:** Grade 3: LD_{50} = 50 to 500 mg/kg
5.7 **Late Toxicity:** Leukemia
5.8 **Vapor (Gas) Irritant Characteristics:** If present in high concentrations, vapors may cause irritation of eyes or respiratory system. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 4.68 ppm
5.11 **IDLH Value:** 2,000 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 12°F C.C.
6.2 **Flammable Limits in Air:** 1.3%-7.9%
6.3 **Fire Extinguishing Agents:** Dry chemical, foam, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back
6.7 **Ignition Temperature:** 1097°F
6.8 **Electrical Hazard:** Class I, Group D
6.9 **Burning Rate:** 6.0 mm/min.
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 32

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
5 ppm/6 hr/minnow/lethal/distilled water
20 ppm/24 hr/sunfish/TL_m/tap water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 1.2 lb/lb, 10 days
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:**
Industrial pure .....99+%
Thiophene-free .....99+%
Nitration .....99+%
Industrial 90% .....85+%
Reagent .....99+%
9.2 **Storage Temperature:** Open
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-T-U-V-W

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Flammable liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	3
Water Pollution	
Human Toxicity	3
Aquatic Toxicity	1
Aesthetic Effect	3
Reactivity	
Other Chemicals	2
Water	1
Self Reaction	0

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** 78.11
12.3 **Boiling Point at 1 atm:** 176°F = 80.1°C = 353.3°K
12.4 **Freezing Point:** 42.0°F = 5.5°C = 278.7°K
12.5 **Critical Temperature:** 552.0°F = 288.9°C = 562.1°K
12.6 **Critical Pressure:** 710 psia = 48.3 atm = 4.89 MN/m²
12.7 **Specific Gravity:** 0.879 at 20°C (liquid)
12.8 **Liquid Surface Tension:** 28.9 dynes/cm = 0.0289 N/m at 20°C
12.9 **Liquid Water Interfacial Tension:** 35.0 dynes/cm = 0.035 N/m at 20°C
12.10 **Vapor (Gas) Specific Gravity:** 2.7
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.061
12.12 **Latent Heat of Vaporization:** 169 Btu/lb = 94.1 cal/g = 3.94 X 10⁵ J/kg
12.13 **Heat of Combustion:** −17,460 Btu/lb = −9698 cal/g = −406.0 X 10⁵ J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** 30.45 cal/g
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** 3.22 psia

NOTES

POLYCHLORINATED BIPHENYL

PCB

Common Synonyms	Oily liquid to solid powder	Light yellow liquid, or white powder	Weak odor
PCB Chlorinated biphenyl Arochlor Halogenated waxes Polychloropolyphenyls	Sinks in water.		

Stop discharge if possible. Keep people away.
Avoid contact with liquid and solid.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
Extinguish with water, foam, dry chemical, or carbon dioxide.

Exposure

CALL FOR MEDICAL AID.

LIQUID OR SOLID
Irritating to skin and eyes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-water contaminant
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** None
2.2 **Class:** Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Not listed
3.2 **Formula:** $(C_{12}H_{10-n})Cl_n$
3.3 **IMO/UN Designation:** Not listed
3.4 **DOT ID No.:** 2315
3.5 **CAS Registry No.:** 1336-36-3

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid or solid
4.2 **Color:** Pale yellow (liquid); colorless (solid)
4.3 **Odor:** Practically odorless

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Gloves and protective garments.
5.2 **Symptoms Following Exposure:** Acne from skin contact.
5.3 **Treatment of Exposure:** SKIN: wash with soap and water.
5.4 **Threshold Limit Value:** 0.5 to 1.0 mg/m³
5.5 **Short Term Inhalation Limits:** Data not available
5.6 **Toxicity by Ingestion:** Grade 2; oral rat LD_{50} = 3980 mg/kg
5.7 **Late Toxicity:** Causes chromosomal abnormalities in rats, birth defects in birds
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause severe irritation of eyes and throat and cause eye and lung injury. They cannot be tolerated even at low concentrations.
5.9 **Liquid or Solid Irritant Characteristics:** Contact with skin may cause irritation.
5.10 **Odor Threshold:** Data not available
5.11 **IDLH Value:** 5 to 10 mg/m³

6. FIRE HAZARDS

6.1 **Flash Point:** >286°F
6.2 **Flammable Limits in Air:** Data not available
6.3 **Fire Extinguishing Agents:** Water, foam, dry chemical, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Irritating gases are generated in fires.
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Data not available
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** Data not available
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** Data not available

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 0.278 ppm/96 hr/bluegill/TL_m/fresh water
0.005 ppm/336-1080 hr/pinfish/TL_m/salt water
8.2 **Waterfowl Toxicity:** LD_{50} 2000 ppm (mallard duck)
8.3 **Biological Oxygen Demand (BOD):** Very low
8.4 **Food Chain Concentration Potential:** High

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** 11 grades (some liquid, some solids) which differ primarily in their chlorine content (20%-68% by weight)
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

II

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** ORM-E
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:** Not listed

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Solid
12.2 **Molecular Weight:** Not pertinent
12.3 **Boiling Point at 1 atm:** Very high
12.4 **Freezing Point:** Not pertinent
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** 1.3—1.8 at 20°C (liquid)
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Not pertinent
12.13 **Heat of Combustion:** Not pertinent
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

TRICHLOROETHANE

TCE

Common Synonyms	Watery liquid	Colorless	Sweet odor
1,1,1-Trichloroethane Methylchloroform Aerothene Chlorothene	Sinks in water. Irritating vapor is produced.		

Stop discharge if possible. Keep people away.
Avoid contact with liquid and vapor.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
POISONOUS GASES ARE PRODUCED IN FIRE.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, carbon dioxide, or foam.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness or difficult breathing.

Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, may produce nausea.

Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** None
2.2 **Class:** Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Halogenated hydrocarbon
3.2 **Formula:** CH_3CCl_3
3.3 **IMO/UN Designation:** Not listed
3.4 **DOT ID No.:** 2831
3.5 **CAS Registry No.:** 71-55-6

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Chloroform-like; sweetish

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Organic vapor-acid gas canister; self-contained breathing apparatus for emergencies; neoprene or polyvinyl-alcohol-type gloves; chemical safety goggles and face shield; neoprene safety shoes (or leather safety shoes plus neoprene footwear); neoprene or polyvinyl alcohol suit or apron for splash protection.

5.2 **Symptoms Following Exposure:** INHALATION: symptoms range from loss of equilibrium and incoordination to loss of consciousness; high concentration can be fatal due to simple asphyxiation combined with loss of consciousness. INGESTION: produces effects similar to inhalation and may cause some feeling of nausea. EYES: slightly irritating and lachrymatory. SKIN: defatting action may cause dermatitis.

5.3 **Treatment of Exposure:** Get medical attention for all eye exposures and any other serious over-exposures. Do NOT administer adrenalin or epinephrine; otherwise, treatment is symptomatic. INHALATION: remove victim to fresh air; if necessary, apply artificial respiration and/or administer oxygen. INGESTION: have victim drink water and induce vomiting. EYES: flush thoroughly with water. SKIN: remove contaminated clothing and wash exposed area thoroughly with soap and warm water.

5.4 **Threshold Limit Value:** 350 ppm
5.5 **Short Term Inhalation Limits:** 1,000 ppm for 60 min. in man
5.6 **Toxicity by Ingestion:** Grade 1; LD_{50} = 5 to 15 g/kg (rat, mouse, rabbit, guinea pig)
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 100 ppm
5.11 **IDLH Value:** 1,000 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** Data not available
6.2 **Flammable Limits in Air:** 7%-16%
6.3 **Fire Extinguishing Agents:** Dry chemical, foam, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Toxic and irritating gases are generated in fires.
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** 932°F
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** (est.) 2.9 mm/min.
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** Reacts slowly, releasing corrosive hydrochloric acid.
7.2 **Reactivity with Common Materials:** Corrodes aluminum, but reaction is not hazardous.
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 36

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 75-150 ppm/*/pinfish/TL_m/salt water
*Time period not specified.
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Uninhibited; inhibited; industrial inhibited; white room; cold cleaning
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-X-Y

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** ORM-A
11.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	1
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	0

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	1
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** 133.41
12.3 **Boiling Point at 1 atm:** 165°F = 74°C = 347°K
12.4 **Freezing Point:** <−38°F = <−39°C = <234°K
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** 1.31 at 20°C (liquid)
12.8 **Liquid Surface Tension:** 25.4 dynes/cm = 0.0254 N/m at 20°C
12.9 **Liquid Water Interfacial Tension:** (est.) 45 dynes/cm = 0.045 N/m at 20°C
12.10 **Vapor (Gas) Specific Gravity:** 4.6
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.104
12.12 **Latent Heat of Vaporization:** 100 Btu/lb = 58 cal/g = 2.4 X 10^4 J/kg
12.13 **Heat of Combustion:** (est.) 4700 Btu/lb = 2600 cal/g = 110 X 10^4 J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** 4.0 psia

NOTES

APPENDIX B

FIELD FORMS USED IN RI ACTIVITIES

HALLIBURTON NUS
Environmental Corporation

Site Entry Log

SITE: _____ DATE: _____

NAME	REPRESENTING	TIME IN (HOURS)	TIME OUT (HOURS)	INITIALS

Halliburton NUS CORPORATION

Field Instrument Calibration Log

INSTRUMENT NAME: _____

SERIAL NO.: _____ MODEL NO.: _____ DECAL NO.: _____

CALIBRATION DATE	INITIAL READING	PROCEDURE	FINAL READING	SIGNATURE	COMMENTS

HNUS FORM 0012

Halliburton NUS CORPORATION

YSI pH/Conductivity/Temperature Meter Field Calibration Log

SERIAL NO.: _____ MODEL NO.: _____ DECAL NO.: _____

SITE NAME: _____ JOB NO.: _____

CALIBRATION DATE	INITIAL READINGS				PROCEDURES	FINAL READINGS		SIGNATURE	COMMENTS
	pH = 4.0 (Buffer Lot #)	pH = 7.0 (Buffer Lot #)	Conductivity m /cm (Lot #)	Temperature (°C)		pH = 4.0	pH = 7.0		
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				

HNUS FORM 0010

Halliburton NUS CORPORATION

Photovac "Microtip" Field Calibration Log

SERIAL NO.: _____ MODEL NO.: _____ DECAL NO.: _____

SITE NAME: _____ JOB NO.: _____

CALIBRATION DATE	INITIAL READING Benzene Equiv. (ppm)	STANDARD GAS - ISOBUTYLENE	FINAL SETTINGS(1) Benzene Equiv. (ppm)	SIGNATURE	COMMENTS
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			
		Lot # _____ Conc = _____ppm			

(1) $\frac{\text{Isobutylene Conc. (ppm)}}{1.78}$ = Conc. of standard gas in Benzene Equivalents (ppm)

HNUS FORM 0011

Halliburton NUS CORPORATION

YSI Dissolved Oxygen Meter Field Calibration Log

SERIAL NO. _____ MODEL NO. _____ DECAL NO. _____

SITE NAME: _____ JOB NO.: _____

CALIBRATION DATE	INITIAL READINGS		PROCEDURE	FINAL SETTINGS		SIGNATURE	COMMENTS
	Dissolved Oxygen (mg/L)	Temperature (°C)		Dissolved Oxygen (mg/L)	Temperature (°C)		
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				

NUS FORM 0013

BORING LOG

NUS CORPORATION

PROJECT: _____ LOCATION: _____ DRILLED BY: _____ BORING NO.: _____

DATE STARTED: _____ INCLINATION: _____ LOGGED BY: _____ GROUND ELEV.: _____

DATE COMPLETED: _____ BEARING: _____ CHECKED BY: _____ TOTAL DEPTH: _____

ELEV. feet	DEPTH feet	SAMPLE TYPE-NO.	SAMPLE BLOWS PER 6"	SAMPLE PEN. in.	SAMPLE REC. in.	REMARKS ON ADVANCE OF BORING	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS

LEGEND:
TYPE-NO - Type of sample
C - Rock core sample
S - Split barrel sample
BLOWS PER 6" - 140 lb. hammer falling 30" to drive a split barrel sampler; coring time per foot of rock
PEN - Penetration length of sampler
REC - Length of sample recovered
∇ - Natural ground water table

NOTES:

DATE: _____ PROJECT NO.: _____

PAGE: _____ OF _____ BORING NO.: _____

OVERBURDEN WELL CONSTRUCTION LOG

HALLIBURTON NUS ENVIRONMENTAL CORPORATION

PROJECT: _____ PAGE: 1 OF 1

PROJECT LOCATION: _____

CLIENT: _____ BORING NO.: MW

CONTRACTOR: _____ DRILLER: _____ BORING LOCATION: _____

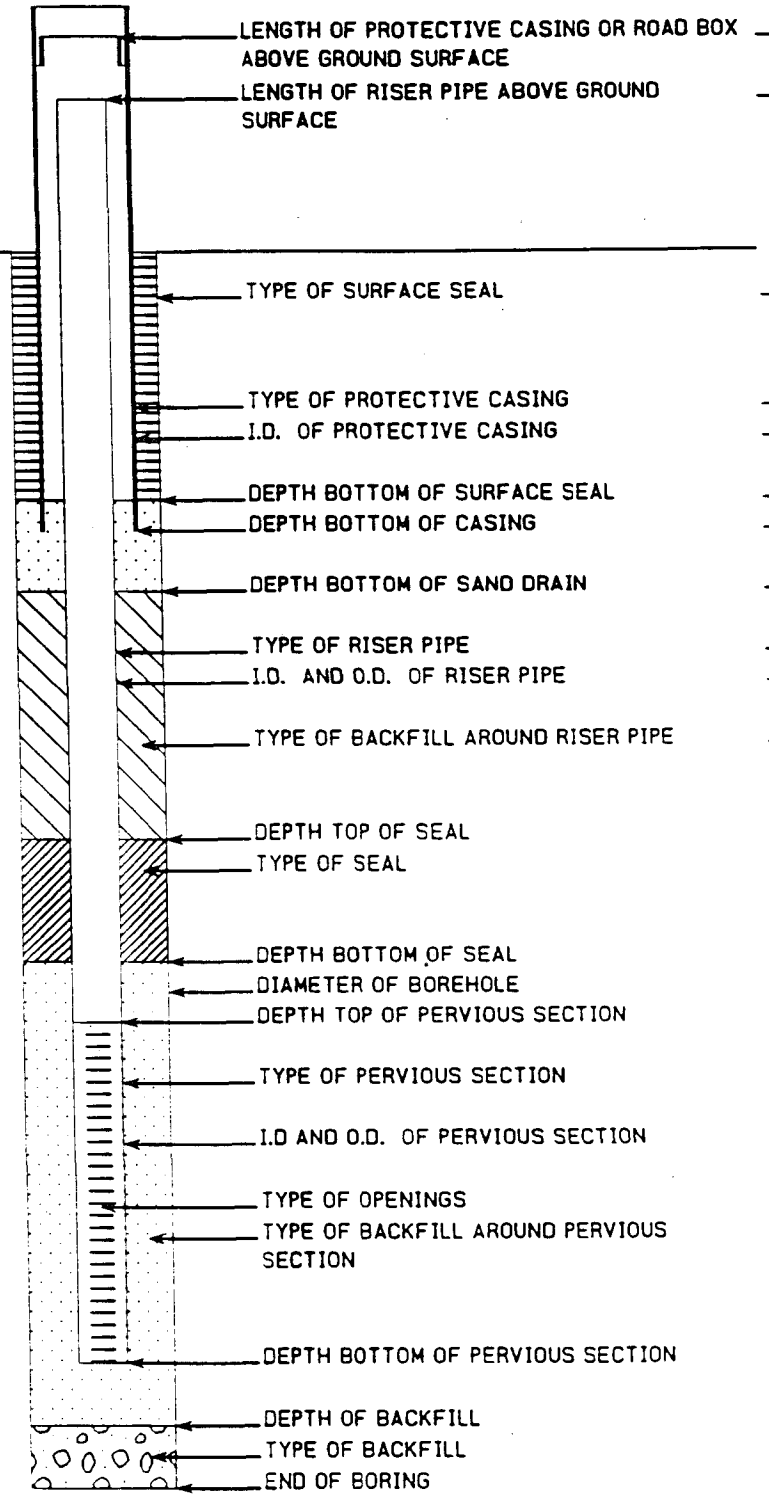
LOGGED BY: _____ DATE: _____ PROJECT NO.: _____

CHECKED BY: _____ DATE: _____

ELEVATION TOP OF PROTECTIVE CASING _____

ELEVATION TOP OF RISER PIPE _____

GROUND ELEVATION _____



LENGTH OF PROTECTIVE CASING OR ROAD BOX ABOVE GROUND SURFACE _____

LENGTH OF RISER PIPE ABOVE GROUND SURFACE _____

TYPE OF SURFACE SEAL _____

TYPE OF PROTECTIVE CASING _____

I.D. OF PROTECTIVE CASING _____

DEPTH BOTTOM OF SURFACE SEAL _____

DEPTH BOTTOM OF CASING _____

DEPTH BOTTOM OF SAND DRAIN _____

TYPE OF RISER PIPE _____

I.D. AND O.D. OF RISER PIPE _____

TYPE OF BACKFILL AROUND RISER PIPE _____

DEPTH TOP OF SEAL _____

TYPE OF SEAL _____

DEPTH BOTTOM OF SEAL _____

DIAMETER OF BOREHOLE _____

DEPTH TOP OF PERVIOUS SECTION _____

TYPE OF PERVIOUS SECTION _____

I.D AND O.D. OF PERVIOUS SECTION _____

TYPE OF OPENINGS _____

TYPE OF BACKFILL AROUND PERVIOUS SECTION _____

DEPTH BOTTOM OF PERVIOUS SECTION _____

DEPTH OF BACKFILL _____

TYPE OF BACKFILL _____

END OF BORING _____

BEDROCK WELL CONSTRUCTION LOG

HALLIBURTON NUS ENVIRONMENTAL CORPORATION

PROJECT: _____ PAGE: 1 OF 1

PROJECT LOCATION: _____

CLIENT: _____ BORING NO.: MW

CONTRACTOR: _____ DRILLER: _____ BORING LOCATION: _____

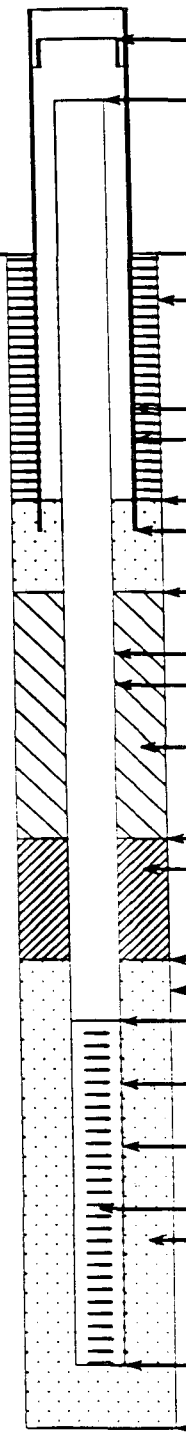
LOGGED BY: _____ DATE: _____ PROJECT NO.: _____

CHECKED BY: _____ DATE: _____

ELEVATION TOP OF PROTECTIVE CASING _____

ELEVATION TOP OF RISER PIPE _____

GROUND ELEVATION _____



LENGTH OF PROTECTIVE CASING OR ROAD BOX ABOVE GROUND SURFACE _____

LENGTH OF RISER PIPE ABOVE GROUND SURFACE _____

TYPE OF SURFACE SEAL _____

TYPE OF PROTECTIVE CASING _____

I.D. OF PROTECTIVE CASING _____

DEPTH BOTTOM OF SURFACE SEAL _____

DEPTH BOTTOM OF CASING _____

DEPTH BOTTOM OF SAND DRAIN _____

General soil conditions (not to scale)

TYPE OF RISER PIPE _____

I.D. AND O.D. OF RISER PIPE _____

TYPE OF BACKFILL AROUND RISER PIPE _____

DEPTH TOP OF SEAL _____

TYPE OF SEAL _____

DEPTH BOTTOM OF SEAL _____

DIAMETER OF BOREHOLE _____

DEPTH TOP OF PERVIOUS SECTION _____

TYPE OF PERVIOUS SECTION _____

I.D AND O.D. OF PERVIOUS SECTION _____

TYPE OF OPENINGS _____

TYPE OF BACKFILL AROUND PERVIOUS SECTION _____

DEPTH BOTTOM OF PERVIOUS SECTION _____

END OF BORING _____

Halliburton NUS CORPORATION

DAILY ACTIVITIES RECORD - FIELD INVESTIGATION

PROJECT NAME: _____ PROJECT NO.: _____

CLIENT: _____ LOCATION: _____

DATE: _____ ARRIVAL TIME: _____ DEPARTURE TIME: _____

DRILLER: _____

BORING NO.: _____ HNUS REPRESENTATIVE: _____

ITEM(1)	QUANTITY TODAY(2)		
1. Mobilization/Demobilization	Lump Sum		
	LEVEL D	LEVEL C	LEVEL B
2. Overburden Drilling/Hollow Stem Auger	_____ feet	_____ feet	_____ feet
3. Split Barrel Sampling	_____ samples	_____ samples	_____ samples
4. Monitoring Well Construction/Installation	_____ feet	_____ feet	_____ feet
5. Backfill/Abandonment	_____ feet	_____ feet	_____ feet
6. Well Development	_____ hours	_____ hours	_____ hours
7. Waste Containerization (55 gallon drums)	_____ drums	_____ drums	_____ drums

COMMENTS: _____

(1) As listed in specs

(2) Per foot items to nearest foot; hourly items to nearest quarter hour.

APPROVED BY:

_____ DATE

_____ HNUS FIELD REPRESENTATIVE

_____ DATE

_____ DRILLER REPRESENTATIVE

HNUS FORM 0024

Halliburton NUS CORPORATION

WEEKLY ACTIVITIES SUMMARY - FIELD INVESTIGATION

PROJECT NAME: _____ PROJECT NO.: _____

CLIENT: _____ LOCATION: _____

WEEK OF: _____ DRILLER: _____

ITEM (1)	MON(2)	TUE(2)	WED(2)	THUR(2)	FRI(2)	WEEKLY(2) QUANTITY SUBTOTAL	CUMULATIVE QUANTITY(2) TO DATE
1. Mobilization/Demobilization							
2. Overburden Drilling/Hollow Stem Auger							
3. Split Barrel Sampling (samples)							
4. Monitoring Well Construction/Installation (ft)							
5. Backfill/Abandonment							
6. Well Development (hours)							
7. Waste Containerization (55 gallon drums)							

COMMENTS: _____

(1) As listed in specs
(2) Per foot items to nearest foot; hourly items to nearest quarter hour. All items are asssumed to be Level D unless otherwise noted

SUMMARIZED FROM "DAILY ACTIVITIES RECORD" FORMS

SUMMARIZED BY:

_____ DATE

_____ HNUS FIELD REPRESENTATIVE

HNUS FORM 0025

Halliburton NUS CORPORATION

SAMPLE LOG SHEET - SOLID PHASE

Site Name: _____ HNUS Project Job No.: _____

Sample Number: _____ Replicate/Duplicate No.: _____ (if applicable)

Sample Method: _____

Depth Sampled: _____ feet

Sample Date & Time: / / _____ hrs

Samplers: _____

Data Recorded By: (Signature) _____

TYPE OF SAMPLE: (Check all that apply)

- ___ Soil
- ___ Sediment
- ___ Lagoon/Pond
- ___ Grab
- ___ Composite
- ___ Trip Blank*
- ___ Rinsate Blank*
- ___ Field Duplicate Collected
- ___ Other (Specify): _____

*Include sample source & lot no.

Description: (Sand, Clay, Dry, Moist, Wet, Etc.)

SAMPLE DATA/REMARKS:

ANALYSIS:	BOTTLE LOT NO.	TRAFFIC REPORT NO. ORGANIC	TRAFFIC REPORT NO. INORGANIC	EPA SAS IDENTIFIER NO.	EPA TAG NO.

HNUS FORM 0015

Page _____ of _____

Halliburton NUS CORPORATION

SAMPLE LOG SHEET - LIQUID PHASE

Page ____ of ____

Site Name: _____ HNUS Project Job No.: _____

Sample Number: _____ Sample Station: _____ (if applicable)

Sample Method: _____

Depth Sampled: _____ feet Total Depth _____ feet (SW only)

Sample Date & Time: / / _____ hours

Samplers: _____

Data Recorded By: (Signature) _____

TYPE OF SAMPLE: (Check all that apply)

____ Groundwater
____ Surface Water
____ Residential Supply
____ Grab
____ Composite
____ Trip Blank*
____ Rinsate Blank*
____ Field Duplicate Collected
____ Other (Specify): _____

*Include sample source & lot no.

WELL PURGE DATA:

Well Depth _____ (ft) Purge Start _____ (hrs.)

Inside Diameter _____ (in) Purge Stop Time _____ (hrs.)

Water Level _____ (ft) Total Gal. Purged _____

Well Volume _____ (gal) Purge Method _____

Microtip/OVA Monitor Reading: _____ ppm

Sampling/Purge Data:

Volume #	Temp °C	pH	Spec. Cond mill-mhos/cm	DO mg/L
0				
1				
2				
3				
4				

Color: Turbidity: (CLR/SLCLDY/CLDY/OPAQ)

ANALYSIS	BOTTLE LOT NO.	TRAFFIC REPORT NO. ORGANIC	TRAFFIC REPORT NO. INORGANIC	EPA SAS IDENTIFIER NO.	EPA TAG NO.

HNUS FORM 0016

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET - "LOW-FLOW" GROUNDWATER

Site Name: _____

Sample Number: _____

HNUS Project Job No : _____

Sample Station: _____ (if applicable)

Sample Method: _____

Depth Sampled: _____ feet Screened Interval Depth _____ feet

Sample Date & Time: / / _____ hours

Samplers: _____

Data Recorded By: (Signature) _____

TYPE OF SAMPLE: (Check all that apply)

___ Groundwater
___ Grab
___ Composite
___ Other (Specify): _____

___ Trip Blank*
___ Rinsate Blank*
___ Field Duplicate Collected

*Include sample source & lot no.

TIME	WL	TEMP	COND	PH	TURBIDITY	DISSOLVED OXYGEN	VOLUME

Microtip Reading:

ANALYSIS	BOTTLE LOT NO.	TRAFFIC REPORT NO. ORGANIC	TRAFFIC REPORT NO. INORGANIC	EPA SAS IDENTIFIER NO.	EPA TAG NO.

Halliburton NUS CORPORATION

Groundwater Level Measurement Sheet

SITE INFORMATION

Project Name: _____

Project No.: _____

Personnel: _____

Date: _____

Municipality: _____

County: _____

State: _____

Street or Map Location _____

(If Off-Site) _____

WEATHER CONDITIONS AND EQUIPMENT

Temperature Range: _____

Precipitation: _____

Barometric Pressure: _____

Tidally-Influenced: [ ] Yes [ ] No

Equipment No.: _____

Equipment Name: _____

Latest Calibration Date: _____

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

*All elevations to nearest 0.01 foot from top of PVC unless otherwise noted.

HNUS FORM 0023

HALLIBURTON NUS
Environmental Corporation

WELL INSPECTION AND GROUNDWATER LEVEL MEASUREMENT SHEET

WELL NUMBER: _____ PROJECT NAME: _____

DATE/TIME _____ PROJECT NUMBER: _____

INSPECTED BY: _____

_____

VENT WELL

MONITORING INSTRUMENT READING _____

LEL/O2 READING _____

WELL INSPECTION/GROUNDWATER LEVEL MEASUREMENT

WELL DEPTH (FEET FROM TOP OF PVC) _____

WATER LEVEL DEPTH (FEET FROM TOP OF PVC) _____

WELL STICK-UP _____

CASING STICK-UP (FEET) _____

WELL DIAMETER (INCHES) _____

WELL CONSTRUCTION (PVC, STEEL, ETC.) _____

LOCKED UPON ARRIVAL?	YES	NO	
LOCK REPLACED?	YES	NO	
OBSTRUCTIONS?	YES	NO	
WELL RELABELED?	YES	NO	
SLUG TEST CONDUCTED?	YES	NO	(If YES, refer to "Hydraulic Conductivity Testing Data Sheet")

GENERAL CONDITION/COMMENTS: _____

_____

_____

_____

_____

_____

HALLIBURTON NUS CORP.

SAMPLE COLLECTION SUMMARY RECORD

Page ____ of ____

PROJECT NO.	PROJECT NAME/SAMPLING EVENT	FIELD QC	CASE NO _____
SAMPLERS: (Signature)			SAS NO. _____

DATE	TIME	SAMPLE LOCATION								

HNUS FORM 0018

HALLIBURTON NUS

CHAIN OF CUSTODY RECORD

Page ____ of ____

PROJECT NO	PROJECT NAME/SAMPLING EVENT	NO OF CON-TAINERS							
SAMPLERS: (Signature)									

DATE	TIME	COMP	GRAB	SAMPLE LOCATION								

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED FOR LABORATORY BY: (Signature)	DATE/TIME	REMARKS	

Halliburton NUS CORPORATION

FIELD INVESTIGATION DAILY SUMMARY

PROJECT NAME: _____ PROJECT NO.: _____

CLIENT: _____ LOCATION: _____

DATE: ____/____/____ SUBCONTRACTOR: _____

SITE ACCESS AT _____ HOURS DEPARTED SITE AT _____ HOURS

PERSONNEL ONSITE	REPRESENTING	ARRIVAL TIME (hrs)	DEPARTURE TIME (hrs)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

ACTIVITIES PERFORMED ON ____/____/____ INCLUDED:

_____

_____

_____

_____

_____

ONSITE INCIDENTS/ACCIDENTS (if applicable)

_____

_____

_____

COMMENTS: _____

_____

_____

(1) As listed in specs

_____ DATE

_____ HNUS FIELD REPRESENTATIVE

HNUS FORM 0014

Halliburton NUS CORPORATION

WEEKLY FIELD SUMMARY REPORT

TO: _____ FROM: _____

SITE: _____ JOB NO. _____

DATES: _____ to _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

HNUS FORM 0019

WEEKLY FIELD SUMMARY REPORT (continued)

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

DAY: _____

DATE: _____ WEATHER: _____

PERSONNEL ONSITE: _____

SITE ACTIVITIES: _____

HALLIBURTON NUS
Environmental Corporation

FIELD MODIFICATION RECORD

Site Name | Assignment | Location

EPA Work Assignment Number | Project Number | FMR Number

To: _____ Location: _____ Date: _____

Description:

Reason for Change:

Recommended Disposition:

Field Operations Leader (Signature) | Date

Disposition:

Project Manager (Signature) | Date

Distribution:

Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader
Project File _____-5.4 (original)
Program File 0187-0330

Others as required _____

HALLIBURTON NUS
Environmental Corporation

COMMUNITY RELATIONS CONTACT REPORT

REPORT DATE: _____ JOB NO.: _____

CONTACT NAME: _____ CONTACT DATE: _____

ADDRESS: _____ TELEPHONE: _____

CONTACT PLACE: _____

HNUS/BEI EMPLOYEE CONTACTED: _____

CONTACT CONCERN: _____

_____

_____

_____

ACTION REQUIRED: _____

_____

_____

_____

COMMENTS: _____

_____

_____

_____

CONCERN LEVEL (Circle) HIGH MEDIUM LOW

CONCERN POSITION (Circle) GOVERNMENT CITIZEN PRESS ENVIRON. GP

DISTRIBUTION:

PMO: _____

PROJECT MANAGER: _____

B. HORNE

FILE: _____

APPENDIX C

HNUS CORPORATION STANDARD OPERATING PROCEDURES

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.2	Page 1 of 4
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject EVALUATION OF EXISTING MONITORING WELLS		Approved D. Senovich	

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- 5.1 PRELIMINARY EVALUATION
- 5.2 FIELD INSPECTION

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating existing monitoring wells, and to insure that the validity of data to be collected from these wells is usable during site investigations.

2.0 SCOPE

This procedure is applicable during stages of a site investigation. The procedures are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

The program represents a comprehensive approach to evaluating existing monitoring wells. Because of its comprehensiveness, completion of the program as specified will result in some duplication of effort. The actual level of evaluation program will depend on the data that are available (or which can be made available), the use to which that data will be put (i.e., the data quality objectives), and the effect that data will have on the time, budget and data quality for the overall program.

3.0 GLOSSARY

Data Quality Objectives (DQO) - qualitative and quantitative statements specifying data quality (i.e. measurement of uncertainty) required to support the objectives of the groundwater monitoring program.

4.0 RESPONSIBILITIES

Site Geologist - responsible for overseeing field inspections and for assessing the structural integrity of the wells and related field conditions. The geologist will carry out well evaluation procedures and assess the physical condition of the wells. These results and conclusions concerning the conditions of existing monitoring wells should be discussed with the Site Manager and Field Operation Leader, who together, will then determine which of the existing monitoring wells can be utilized.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology;
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths;
- Satisfactory methods of groundwater sampling and analysis to meet the data quality objectives (DQOs);
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 PRELIMINARY EVALUATION

A necessary first step in evaluating existing monitoring well data will be the study and review of the original work plan for monitoring well installation (if available). This will help to familiarize the geologist with specific site conditions requiring analysis, will promote an understanding of the original purpose of the monitoring wells and will help to determine if the well installation can meet the current DQOs. For example, existing wells may be sufficient for RCRA compliance but not for contaminant plume identification. Of particular interest during this phase of the project will be the rationale for the horizontal location of the wells and the vertical position and length of the monitored interval.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology and will help to establish consistency between hydraulic properties of the well to physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates the distance from prominent site features, or the location of the well on a map;
- The installation dates, drilling methods, well development methods, and contractors;
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-spoon sampling) may be used to estimate bedrock interface;
- The soil profile and stratigraphy;
- The borehole depth and diameter;
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface;
- The total depth of the well;
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval;
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size;

5.2 FIELD INSPECTION

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock;
- The condition of the cement seal surrounding the protective casing;
- The presence of depressions or standing water around the casing;
- The presence of any electrical cable and its connections.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results since the time when leakage started is unknown.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, the steps described above should be taken to rehabilitate the well. After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a PID or FID meter and combustible gas meter to determine the appropriate worker safety level. The following information should be noted:

- Cap function;
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing;
- Presence of a riser cap, method of attachment to casing, and venting of the riser;
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.
- The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. Specific field investigative activities which should be carried out include:
- This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present, the well be should be redeveloped before sampling.
- As a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

6.0 RECORDS

A record of all field procedures, tests and observations should be recorded in a field log book. Entries in the log book should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (±2 lb.) hammer falling 30 inches (±1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailigs, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.
- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.
- Pack and ship accordingly.
- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.
- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.
- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

ATTACHMENT 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	$1\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1\frac{1}{2}$	$\frac{29}{32}$	1.470	905
EX, EXL, EWG, EWM	$1\frac{1}{2}$	$\frac{13}{16}$	1.470	.845
AWT	$1\frac{7}{8}$	$1\frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	$1\frac{7}{8}$	$1\frac{3}{16}$	1.875	1.185
BWT	$2\frac{3}{8}$	$1\frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	$2\frac{3}{8}$	$1\frac{5}{8}$	2.345	1.655
NWT	3	$2\frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	$2\frac{1}{8}$	2.965	2.155
HWT	$3\frac{29}{32}$	$3\frac{3}{16}$	3.889	3.187
HWG	$3\frac{29}{32}$	3	3.889	3.000
$2\frac{3}{4} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{3}{4}$	3.840	2.690
$4 \times 5\frac{1}{2}$	$5\frac{1}{2}$	4	5.435	3.970
$6 \times 7\frac{3}{4}$	$7\frac{3}{4}$	6	7.655	5.970
AX Wire line 1/	$1\frac{7}{8}$	1	1.875	1.000
BX Wire line 1/	$2\frac{3}{8}$	$1\frac{7}{16}$	2.345	1.437
NX Wire line 1/	3	$1\frac{15}{16}$	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 254.
1/ Wire line dimensions and designations may vary according to manufacturer

ATTACHMENT 1
PAGE TWO

Size Designations			Casing coupling					Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

* For hole diameter approximation, assume $\frac{1}{32}$ inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.4.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equpment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.4.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g.,

to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer,the top of the cored interval contained within the box is in the upper left corner of the box,and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

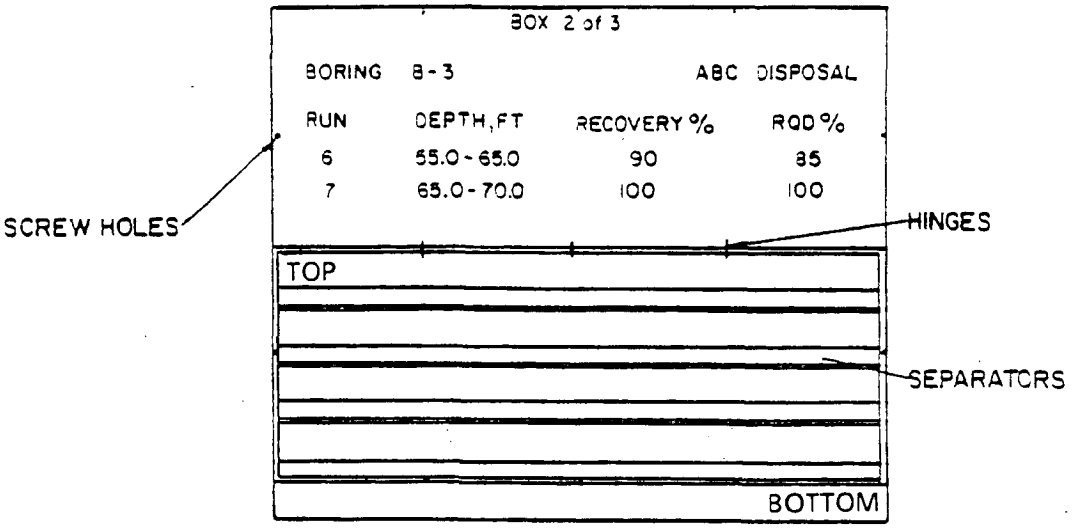
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

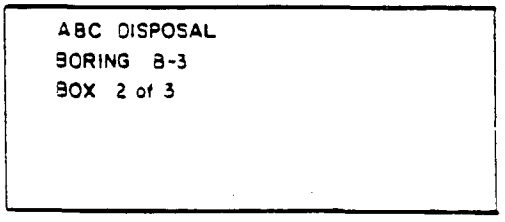
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

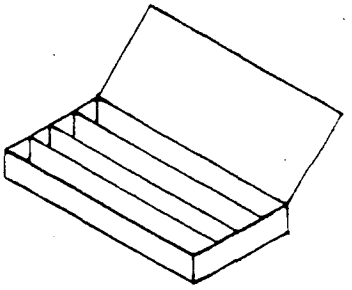
ATTACHMENT 2

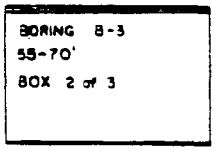


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, Pennsylvania.

American Society for Testing and Materials, 1989. Standrd Practice for Diamond Core Drilling for Site Investigation. ASTM Method D2113-83 (reapproved 1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U.S. Department of the Interior, 1974, Earth Manual, A Water Resources Technical Publication, 810 pages.

Central Mine Equipment Company, Drilling Equipment, St. Louis, Missouri.

7.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.4	Page 1 of 20
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK DRILLING METHODS		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to describe th : nethods, the sequence of operations and the equipment necessary to perform soil and rock borings.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that

logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative

methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injec d to keep down dust).
- The borehole diameter is large, to allow room for prop well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound

hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

- Depth to water cannot accurately be determined if water is used for drilling.

- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided

with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallc drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
Hollow-Stem Augers (Ref 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	-
	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	-
Thin Wall Tube Samplers (Ref 7)	-	2	1 7/8	-
	-	2 1/2	2 3/8	-
	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
	-	5	4 3/4	-
Drill Rods (Ref 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (in)
Driven External Coupled Extra Strong Steel* Casing (Ref 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D (in)	Coupling I.D. (in)
Flush Coupled Casing (Ref 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref 7)	EWM	1 1/2	7/8 **	
	AWM	1 7/8	1 1/8 **	
	BWM	2 3/8	1 5/8 **	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 X 3 7/8	3 7/8	2 11/16	
	4 X 5 1/2	5 1/2	3 15/16	
	6 X 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16 **	
	BQ (wireline)	2 23/64	1 7/16 **	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts shall not be used unless specified by the project manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

RQD % = r/l x 100

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.

- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, siliceous, hematitic)

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to

provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG — **NUS CORPORATION**

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA: .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENESS	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+) > ¼"Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand-clay mixtures.
SANDS 50%(+) < ¼"Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE GRAINED SOILS

More than half of material is SMALLER than No 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)				GROUP SYMBOL	TYPICAL NAMES
Identification procedures on fraction smaller than No 40 sieve size					
SILTS & CLAYS Liquid limit < 50	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X NX (Conventional) Core (~2-1/8" O.D.
Q - NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▼ 12.6' Initial Level ~/Date & Depth

12/18
▼ 12.6' Stabilized Level ~/Date & Depth

EXHIBIT 4-2

Subject	Number	Page
BOREHOLE AND SAMPLE LOGGING	GH-1.5	16 of 26
Revision 2		
Effective Date 05/04/90		

D334901

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff.	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3 '	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-21-87 — DRILLER: B. GOLLIHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

SAMPLE NO. & TYPE/ RQD	DEPTH (ft) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BRKNESS USCS	REMARKS
S-1	0.0	5/6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11/100/.5	0.8/1.0	5.5 / 6.0	M. SOFT TO M. HARD	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM REFUSAL @ 6' 5.5 TOP OF DEC ROCK
									AUGERED TO 15' W/SOLID STEM AUG
									CUTTING MOIST @ ≈8' WATER @ 11' ±
									WL @ 12:10 PM WAS ≈ 9' FROM G.S.
									SET 4" PVC CAS. @ 15.0'
9-21	15.0								
9-22					M. HARD	BRN GRAY	SILTY SHALE - FEW QUARTZ PCS	VBR	SEVERAL 0 PPM Fe STAINED JOINTS ON CORE THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/ VUGS ON LOWER PORTION 23 TO 25 OF CORE
0.2/10.0	①	0%/5	7.9/10.0						
	25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2" Φ SP. SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE.

BORING MW 3A

PAGE 1 OF 3

* See Legend on Back

THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

	SAMPLE NO & TYPE / RQD	DEPTH (ft.) / RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO & JNTS
								(SILTSTONE)		≈26 TO 27 2" VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	99%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 - 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS. WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1.0/10.0	③	100%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI & JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI & JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS _____

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ. CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.)	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	5	0%	1.8/10.0						
	65.0								
				66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/10	6	0%	1.3/10.0						
									POOR RECOVERY FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE. AT 1:50 PM CORED HOLE TO 75' REAMED TWICE DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED 2ND TIME TO 81'. SET WELL 66'-76'.

BORING MW 3A

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* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473 Y — DATE: 7-7-87 — DRILLER: B ERICSSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: SJ CONTI — PENN - DRILL
WATER LEVEL DATA 5.54' @ 8:50 AM 7-23-87 T-PVC — ACKER AD-11
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT.	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BROKENESS USCS	REMARKS (HNU) (HEAD SP)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (OPPM)
S-1		2					TR- COAL FRAG		3/4" Φ FRAG - NEAR OLD
							TR-CC FRAG		RR. LINE.
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO	SANDY SILT - TR ORG TO	SM	MOIST TO WET (OPPM)
	6.5	3				GRAY	SILTY SAND - TR GRAVEL		GRAY SAND @ 6' ±
									MICACEOUS LOOK ± NATURAL
									DRILLER NOTE H2O
	10.0								8-10'
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (OPPM)
	11.5	27					FRAGS (GRAY)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	GM	WET (OPPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/.6	.6/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (OPPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM
									OF SAMPLE

REMARKS START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORINGS USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON
FORD 8000 TRUCK
SAMPLES TAKEN
USING 140 lb wt AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

	SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BROKENESS USCS	REMARKS (HNU)
	S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	GM	WET OPPM
		26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS PRIABLE FIRST CHANGE IN
								TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
										NOTE: MAY SET ZONE 2
7/7		30.0					MOTTLD			CASING ≈ 28'
7/3	S-7		17 / 27	1.4/1.5		V. DENSE	BRN BLUE	SILTY SAND - SOME GRAVEL	SM/	MOIST → WET (OPPM)
		31.5	36				GRAY	TR SS FRAG	GM	SANDSTONE & BLUE
								TR CLAY		GRAY & PRIABLE. SUBROUNDED GRAVEL
										NOT MUCH CLAY - BUT MAY BE SEMI-CON-
		35.0								FINING.
	S-8	35.9	30 / 50/.4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET (OPPM)
								SOME GRAVEL	GM	V. SL. TR CLAY - LESS
								TR. SS. FRAG		THAN S-7 1" Φ FRAG. - MORE
										COARSE SAND THAN ABOVE.
		40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED
	S-9		31 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	HOLDS TOGETHER WHEN MOIST → WET (OPPM)
		41.5	24					SOME GRAVEL - TR	/GM	LITTLE MORE CLAY THAN
								CLAY		S-8 SUBROUNDED GRAVEL
										VERY SLOW DRILLING 40-45 (RIG STALLS)
		45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
	S-10		13 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM/	MOIST → WET (OPPM)
		46.5	50					SOME GRAVEL - TR	GM	1" Φ SIZE - HOLDS TOGETHER WHEN SQUEEZ'D
								CLAY		BUT NOT COHESIVE CLASSIFICATION
										SLOW DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 @

BORING MW013

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BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473Y — DATE: 7-8-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

	SAMPLE NO & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15 / 41	1.9/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	GMY	MOIST - (OPPM)
		51.3	50/3				BRN GRAY	TR CLAY	SM	NOTICE W/ PCS OF BLACK COAL/LIGNITE
										MORE CLAY THAN ABOVE BOTTOMS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11 / 15	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND SOME GRAVEL	SC	MOIST → WET (OPPM)
		56.5	26							NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE; SUB-ROUNDED GRAINS
										FIRST COHESIVE TYPE CLASSIF.
		60.0	40							
	S-13	60.9	50/7.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SOME GRAVEL	SC / GW	MOIST → WET (OPPM) NOT AS MUCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS SET CAS. @ 62'.
		65.0								
7/13	S-14	65.8	37 / 50/3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR. AND ROCK FRAG -	SM / GW	MOIST (OPPM) MORE CLAY THAN RDS
					68.0			TR. CLAY		TOP OF SAMPLE MAX 3/4" D SIZE
							YELLOW BRN			COLOR CHANGE AT ≈ 68' MORE SAND PER DRILLER - BOTTOM OF SEMI CONF LAYER ?
		70.0								
7/14	S-15		39 / 39	1.9/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F TO C) SOME GRAVEL - TR ROCK FRAG.	SC / GC	MOIST → WET (OPPM) 1" MAX GRAVEL. MORE GRAVEL @ 72' PER DRILLER
		71.5	41							

REMARKS: USING HOLLOW STEM TO ADVANCE BORING - WASHING OUT THRU AUGERS, WHEN NEEDED, TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 5:47 PM
SET 6" Φ STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:50 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW 013
PAGE 3 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 437Y — DATE: 7-13-87 / 7-14-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCR. INT 75	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BROKENESS USCS	REMARKS (HNU)
S-16	75.0	28 50/.5	0.9/1.0		V. DENSE	GRAY ORANG	CLAYEY FINE TO C. SAND - SOME	GC	WET (OPPM)
	76.0					BRN	GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Φ PC.
	80.0								NO SAMPLE @ 80' -
									DECIDED TO GO TO 85'
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG	SILTY F. TO C. SAND - SOME	GW	WET (OPPM)
S-17	85.4			85		BRN	GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ≈ 75' TO 85' IN THIS
									BORING.
							BOTM OF HOLE		
							@ 85.0'		

REMARKS S-17 @ 2:20 PM 7-14-87 - METHOD BELOW 6" CASING SPUN 4" Φ - 5 7/8" OD CASING TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved D. Senovich	

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2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall 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 facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.7	Page 1 of 17
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER MONITORING POINT INSTALLATION		Approved D. Senovich	

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3.0 GLOSSARY

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5.3.3 Bedrock Monitoring Wells
5.3.4 Drive Points
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5.4 WELL DEVELOPMENT METHODS

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of

contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells.in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation;-risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. this system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon®
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon®
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
Source: Barcelona et al., 1983
* Trademark of DuPont

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

* See also Attachment A.

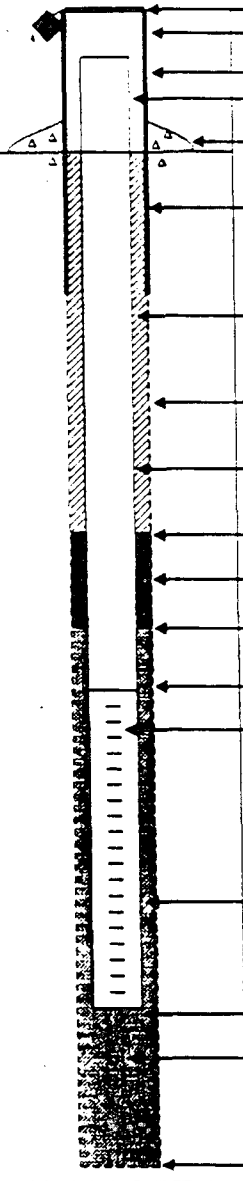
ATTACHMENT C

NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE TWO

NUS CORPORATION

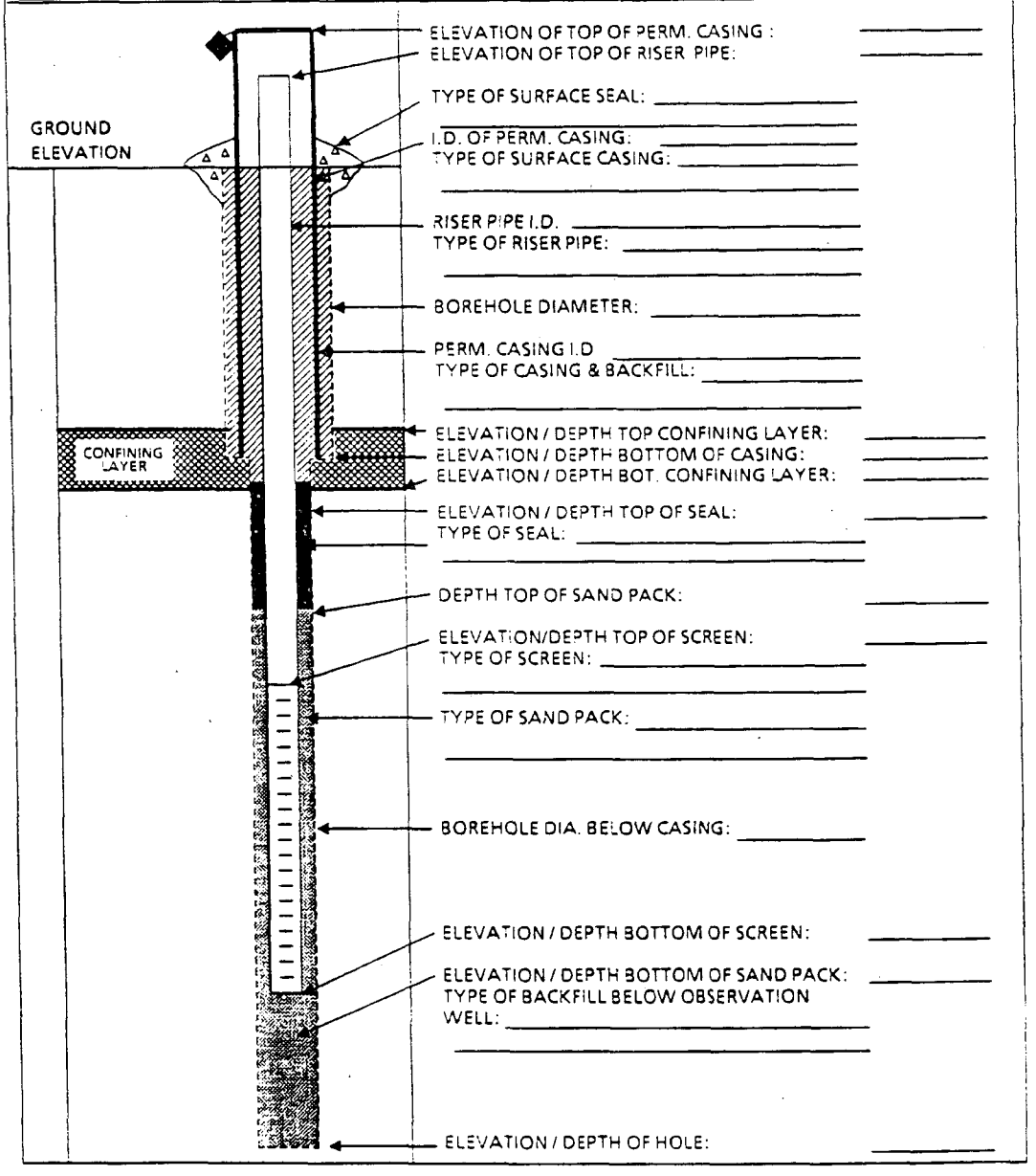
BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

1-5-87

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ATTACHMENT C
PAGE THREE

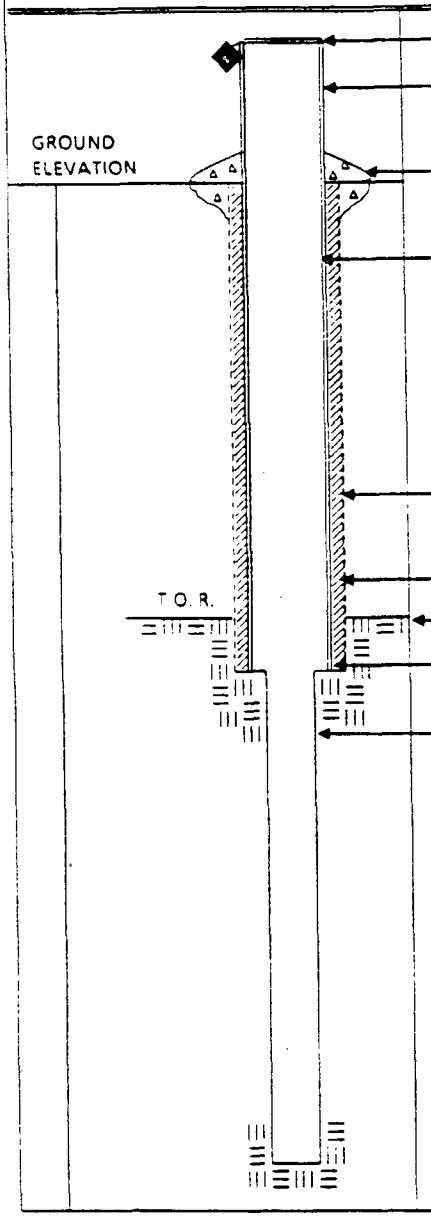
NUS CORPORATION
A Halliburton Company

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____
TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:
_____
_____
_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:
_____
_____
_____

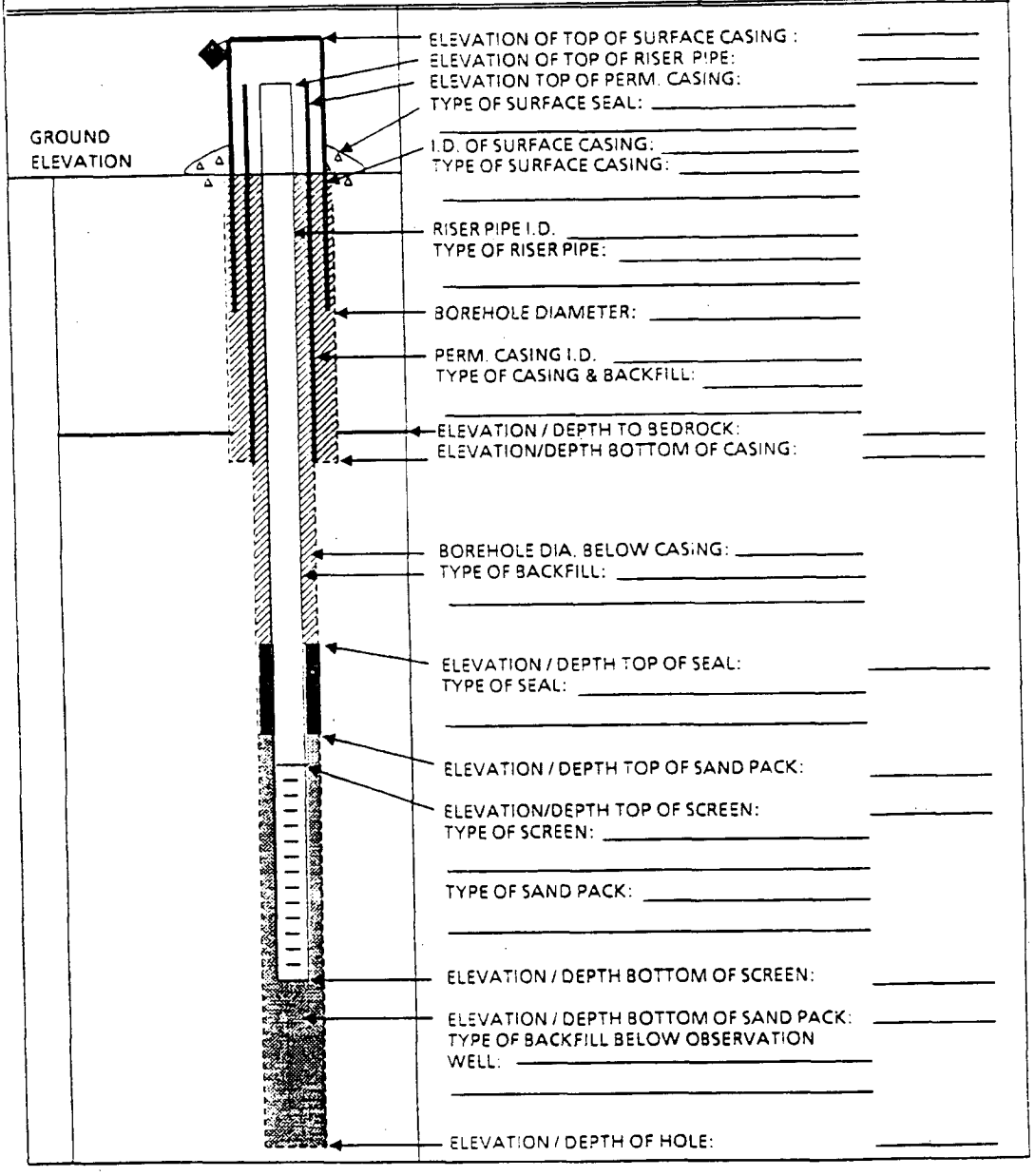
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



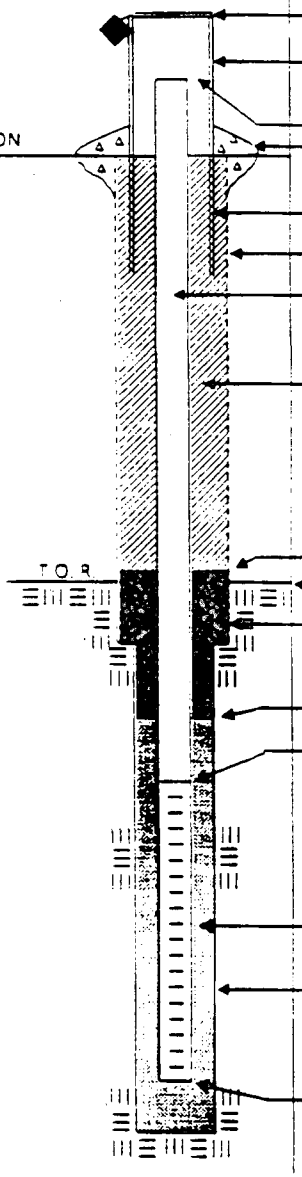
ATTACHMENT C
PAGE FIVE

NUS CORPORATION
A Halliburton Company

BORING NO. _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____
STICK UP OF CASING ABOVE GROUND SURFACE: _____
ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
DIAMETER OF HOLE: _____
RISER PIPE I.D.: _____
TYPE OF RISER PIPE: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
ELEVATION / DEPTH TOP OF BEDROCK: _____
TYPE OF SEAL: _____
ELEVATION / DEPTH TOP OF SAND: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. SCREEN: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK:
CORE / REAM: _____
ELEVATION / DEPTH BOTTOM SCREEN: _____
ELEVATION / DEPTH BOTTOM OF HOLE: _____

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-2.4	Page 1 of 7
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject IN-SITU HYDRAULIC CONDUCTIVITY TESTING		Approved D. Senovich	

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1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly describe

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies required and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system, which might raise doubts regarding the representativeness of future groundwater samples. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow

recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape, coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate

of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 DATA ANALYSIS

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) may be used as the

screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A*. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

* If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
HYDRUALIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO.: .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

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1.0 PURPOSE

This procedure describes methods and equipment commonly-used for collecting environmental samples of surface water and aquatic sediment for either on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.4), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

Collocated Sample - two samples collected at the same time and space. The objective is to check the representativeness of sample collection and the distribution of contaminants. The individual samples are collected in close proximity, at the same location and sampling medium using the same methodology and type of sampling equipment. Collocated samples are not composited. The first sample is collected and all sample containers are filled before proceeding to collect the second sample. Duplicate samples are collected as collocated samples.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

5.0 PROCEDURES

5.1 Introduction

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control

applied during laboratory analyses, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect an adsorption/desorption). The hydrologist developing the sampling plan must therefore, know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to be absorbed by particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

- When sampling for volatile organic contaminants, attempt to minimize agitation and the loss of volatile compounds; if VOA vials do not contain preservative added prior to sample collection (e.g., in-house samples), the sample should be collected directly into the sample container. For CLP VOA samples which contain preservatives added prior to sample collection, carefully decant the sample from another collection jar. Avoid overfilling the vial as this would change the desired preservative concentration. In addition, do not collect VOA samples from a surface water point where water is cascading and subsequently aerating. Ensure that no air space is included in the VOA vial by inverting and shaking the vial after capping to check for air bubbles.

- Always collect samples upstream of any man-made structures such as bridges, culverts, pipes, dams, etc., unless the effect of these on the receiving surface water is the desired objective.

- The desired depth of sample collection may vary with the compounds being sampled for (e.g., dense compounds may "sink", light ones may "float").

- It is suggested that the pre-cleaned sample containers be rinsed once with the water to be sampled prior to collection of the samples. An exception to this would be those sample containers which already contain preservatives prior to sample collection. The rinsate should be disposed of downstream of the sampling point or, if at a pond, on the ground.

- Duplicate samples are collected as collocated samples.

- Samples should not be collected from the surface of a water body unless the sampling is specifically for a known immiscible compound which is expected to be on the water surface. Instead, the sample collection vessel should be inverted, lowered to the desired sample depth, and held at approximately a 45° angle with the mouth of the bottle facing upstream.

- The appropriate field blanks should be stored with field samples throughout field and shipping activities in order to evaluate possible sample contamination problems.

- Under some circumstances (i.e. high turbidity), samples for inorganic analysis may be filtered to obtain dissolved concentrations. All samples should be filtered in the field. Filtering of samples for inorganic analysis allows for an evaluation of naturally dissolved contaminant concentrations without the contribution of suspended particulate matter. All preservatives should be added after filtering. Preservation of unfiltered samples with nitric acid, for example, can cause suspended particles to dissolve and will result in an artificially elevated total concentration of contaminants. The decision to filter or not filter samples will therefore depend on turbidity and what parameter (Total vs. dissolved) is sought. The determination will be presented in the Field Sampling and Analysis Plan. Under no circumstances should samples for volatile organic analysis be filtered.

5.4 Sediment Sampling

5.4.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir.

Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathometry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, downstream of islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). It is therefore important to minimize the loss of low-density "fines" during any sampling process.

5.4.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the chance of metal contamination from the frame of the device.

5.4.3 Sediment Sampling Procedure

Mixing

Regardless of the method of collection, soil samples collected for chemical analysis should be thoroughly mixed before being placed in the appropriate sample containers with the exception of samples collected for volatile organic analysis (VOA) which are not mixed before being placed in the sample container.

For all other samples, the sediment should be removed from the sampling device (dredge, core tube, scoop, etc.) and placed in a stainless steel bowl or pan, then thoroughly mixed using a stainless steel or Teflon spoon. The sediment in the pan should be scraped from the sides, corners, and bottom of the pan, rolled to the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the container. Each quarter of the sample should be mixed individually. Each quarter is then rolled to the center of the container and the entire sample is mixed again.

This procedure should be continued to ensure that all parts of the sample are mixed and that the sample is as homogenous as possible before being placed in the sample containers. Duplicate samples are collected as collocated samples (see SOG SA-1.7)

VOA Analysis

Sediment samples for VOA analyses are not mixed before being placed in the sample container. A representative sample is taken directly from the sampling device to fill the 4 ounce (120 ml) septum sealed container. The sample should be gently folded in the sample container to avoid volatilization while filling to carefully homogenize the sample. The container should be filled completely; no headspace should remain in the sample containers.

Scoop/Trowel/Shovel Collection of Shallow Sediment Samples

Scooping - If the water is wadeable, the easiest and most acceptable way to collect a sediment sample is to scoop the sediment using a stainless steel spoon, trowel, or shovel. This reduces the potential for cross-contamination. This method is accomplished by wading into the stream, and while facing upstream (into the current), scooping the sample along the stream bottom in the upstream direction. If the stream is too deep to wade but less than eight feet

deep, a stainless steel trowel or grain scoop attached to a piece of conduit can be used either from the banks if the stream is narrow or from a boat.

Apply the following procedure:

1. Decontaminate sampling equipment prior to and between sample collections.
2. If the depth of the overlying aqueous layer is greater than six inches, the pH, temperature, and conductivity readings should be collected.
3. insert a trowel, scupula, or shovel into the material to be sampled and collect a sample.
4. When mixing or compositing a series of grab samples, use a stainless steel bowl for mixing.
5. Transfer the sample into an appropriate sample bottle using a scupula or a trowel.

Hand Corer Collection of Deep Sediment Samples

The hand corer is a type of thin-wall corer modified by the addition of a handle to facilitate driving the corer and a check valve on top to prevent washout during retrieval through an overlying water.

Apply the following procedure:

1. Decontaminate the corer prior to and between sample collections.
2. If the depth of the overlying aqueous layer is greater than six inches, the pH, temperature, and conductivity readings should be collected.
3. Force the corer into the sediment/sludge with a smooth continuous motion.
4. Twist the corer, then withdraw it in a single smooth motion.
5. Remove the nosepieces and withdraw the sample into a Pyrex bowl.
6. Transfer the sample into an appropriate sample bottle using a stainless steel lab spoon or equivalent if necessary.

Gravity Corer Collection - Bottom Sediment Samples

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or check valve on the top. The check valve allows water to pass through the corer on descent, but prevents washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration (see Exhibit F). Most corers are constructed of brass and steel and many can accept plastic liners and additional weights.

Apply the following procedure when collecting bottom sludge and sediment samples using a gravity corer:

1. If the depth of the overlying aqueous layer is greater than six inches, the pH, temperature, and conductivity readings should be collected.

2. Attach a decontaminated gravity corer to the required length of decontaminated sample line. Solid braided 5mm (3/16 inch) nylon line is sufficient; however, 20 mm (3/4 inch) nylon is easier to grasp during hand hoisting.

3. Secure the free end of the line to a fixed object to prevent accidental loss of the corer.

4. Allow the corer to free fall through the liquid to the bottom.

5. Retrieve the corer with a smooth continuous lifting motion. Do not bump the corer, as this may result in some sample loss.

6. Remove the nosepiece from the corer and slide the sample out of the corer into a Pyrex baking dish.

7. Transfer the sample into an appropriate sample bottle using a scupula.

Ponar Grab Collection of Bottom Sludge/Sediment Samples

The Ponar Grab sampler is a clamshell type scoop activated by a counter lever system. The shell is opened and latched in place and slowly lowered to the bottom. When tension is released on the lowering cable, the latch releases and the lifting action of the cable on the lever system closed the clamshell. Ponars are capable of sampling most types of sludges and sediments from silts to granular materials. They are available in a "Petite" version with a 232 cm^2 sample area that is light enough to be operated without a winch or crane. Penetration depths will generally not exceed several inches, although deeper penetration is possible. Grab samplers, unlike the corers, are not designed for or capable of collecting undisturbed samples. As a result, material in the upper portion of the sludge or sediment cannot be separated from that at lower depths.

The sampling action of these devices causes agitation currents which may temporarily resuspend some settled solids. This disturbance can be minimized by slowly lowering the sampler the last half meter and allowing a very slow contact with the bottom. However, this may not cause the latch to engage properly. It is advisable to collect sludge or sediment samples only after all overlying water samples have been obtained and in accordance with the producers indicated below:

1. If the depth of the overlying aqueous layer is greater than six inches, the pH, temperature, and conductivity readings should be collected.

2. Attach a decontaminated Ponar to the necessary length of sample line.

3. Secure the free end of the line to a fixed object to prevent the accidental loss of the sampler.

4. Measure and mark the distance to the bottom of the sample line. A secondary mark, 1 meter shallower, will indicate the proximity of the sediment (sludge)/water interface, so that the lowering rate can be reduced, thus preventing unnecessary bottom disturbance.

5. Open the sampler jaws until they are latched. From this point on, support the sampler by its lift line or the sampler will be tripped and the jaws will close.

6. Begin lowering the sampler until the proximity mark is reached. Slow the rate of descent through the last meter until contact is felt.

7. Allow the sample line to slack several centimeters. In strong currents, more slack may be necessary to release the latch mechanism.

8. Slowly raise the dredge clear of the surface.

9. Place the Ponar into a Pyrex baking dish and open. Lift the Ponar clear of the dish.

10. Collect a suitable aliquot with a stainless steel lab spoon or equivalent and place the sample into the appropriate sample bottle.

6.0 RECORDS

Records which must be maintained during sampling activity include, but are not limited to, sample documentation, chain-of-custody records, and sample shipment documents. These procedures must be maintained in accordance with Standard Operating Guidelines SA-6.1 and SA-6.4. Measurements and observations made in the field should also be documented in the field logbook and sample logsheets.

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1.0 PURPOSE

The purpose of this procedure is to present methodologies for surveying and sampling terrestrial vegetation and wildlife at hazardous waste sites.

2.0 SCOPE

The methodologies described in this procedure are appropriate for: identifying perturbations of terrestrial ecological communities which potentially relate to hazardous waste contamination; identifying potential transport mechanisms and food chain linkages for substances of public health concern; and providing the input to evaluate the feasibility and risks of remedial design alternatives. Methodologies presented herein cannot be assumed appropriate for all sites, because of site-specific health and safety constraints.

3.0 GLOSSARY

Community - Populations of plant and animal species which occur together over a given area.

Food Chain - The various pathways involved in transfer of food substances from the abiotic environment or from one organism or group of organisms to another organism or group of organisms.

Transport Mechanisms - The processes by which energy or substances move from one location to another. Can also refer to movement within an organism.

Wetlands - Areas of open shallow water or land vegetated by assemblages of plant species adapted to standing water, saturated soil or regular flooding. Methodological definition is presented in the January 10, 1989 "Federal Manual for Identifying and Delineating Jurisdictional Wetlands."

4.0 RESPONSIBILITIES

Site Manager - Responsible for ensuring that project-specific plans are reviewed by a qualified ecologist and the site Health and Safety Officer, and that plans and their implementation are in compliance with this guideline.

Project Biologist - Responsible for developing and implementing the sampling program, and interpreting the results of the program.

5.0 PROCEDURES

5.1 PROGRAM DESIGN

The site-specific terrestrial ecology field program will be part of the Field Sampling and Analysis Plan and should be designed after the following tasks have been completed:

- Determination by the Site Manager and project ecologist of the objectives of ecological field investigations;
- Review and analysis of all available site-specific information; and
- Consultation with the site Health and Safety Officer (HSO).

The objectives of most terrestrial ecology studies for hazardous waste site investigations can be met with utilization of available information and qualitative methodologies comprising a General Field Survey. In these instances, program design can be accomplished by the field biologist with review by the project ecologist and the HSO.

At those sites where quantitative information or sample collection is deemed necessary, the field program should be designed with input from a statistician. This is required not only to ensure usefulness of data collected, but also to minimize time spent in the field.

5.2 DATA RECORDING

Standard terrestrial ecology field data sheets (Attachment A identifies the types of forms needed to conduct quantitative plant sampling) should be used for General Field Surveys. In some instances (e.g., high winds or dense understory vegetation), compact bound water-resistant notebooks may be more appropriate. One page of each notebook should list all the information required to be recorded at each sampling or observation station, for reference while in the field.

Some investigations may require specially-designed data forms. These should include the following, at a minimum:

- EPA Project Number, Site Name, and Location;
- Date and Time;
- Recorder (Investigator);
- Station location;
- Sample description and/or sample number, as appropriate;
- Weather conditions; and
- Record of any photographs taken.

5.3 PRE-FIELD INVESTIGATION ANALYSES

Prior to the field effort, all relevant available information should be reviewed. This phase is particularly important for hazardous waste site studies because typically employed field accessories such as binoculars, camera and field keys are difficult to use at sites of level C, B or A. At many sites, the quality and quantity of information obtained will be limited by the investigator's ability to identify plant and wildlife habitat features through a respirator mask. Hence, the pre-field investigation should include the following:

- Preliminary map or a listing of vegetation community types or wildlife habitat types likely to be encountered.

- Location of known important habitats or communities (e.g., wetlands, extensive undisturbed natural areas, and habitat for game species); and

- Access routes (paths, trails accommodating all terrain vehicles, etc.) as well as emergency egress routes and safety stations.

Sources of information to be sought and consulted should include, but are not limited to, the following:

- Aerial photography;
- USGS topographic maps;
- USGS County soil survey;
- Historical flood records and 100-year flood insurance maps;
- State wetland maps;
- Observations and photographs obtained by previous investigators (e.g., FIT team or site reconnaissance survey);
- County extension agents for wildlife and forestry data;
- State field biologists;
- Published literature on natural vegetation (e.g., Kuchler, 1964; Eyre, 1980; Braun, 1950); and
- State or federal endangered species specialists where appropriate.

5.4 GENERAL FIELD SURVEY

The General Field Survey comprises a series of observations and measurements recorded at plots located to achieve a representative sampling of the site and coverage of any known important areas. Standard quantitative data sheets (see Attachment A) should be compacted at each plot location; however, if time and cost is of a concern, then a qualitative study using site characterization sheets (Attachment B) may be an option.

Vegetation observations should include a listing of characteristic species by strata:

- Lower stratum includes dominant herbaceous species and those woody plants 50 cm (knee-high) or less high;
- Middle stratum includes woody plants higher than 50 cm and of stem diameter less than 2.5 cm;
- Lower canopy stratum includes woody plants with stems of diameter ranging from (2.5 cm to 10 cm) 1 inch to 4 inches at chest height; and
- Upper canopy stratum includes trees with stem diameter greater than 10 cm (4 inches).

Emphasis is on plant species which, because of their abundance appear to define a community type; are potentially part of the human food chain (e.g., berries and nuts); or are consumed by game species. Wetland communities warrant greater detail because they can constitute important wildlife habitat, particularly for waterfowl, and are likely sinks for water-borne contaminants. At a minimum, the field investigator should record sufficient data for applying in a qualitative manner the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands."

Observations relating to wildlife may also be recorded. In addition to actual sightings, observations includes tracks, dens, nests, scat, browsing signs, etc. Particular attention should be accorded to game species, which can constitute a link between contaminants and the human food chain. Important classes of game species to be considered include waterfowl, mourning dove, upland game birds, deer, rabbit and squirrel. Waterfowl, are of particular concern at hazardous waste sites since they can be abundant, are mobile, utilize wetland habitats serving as contaminant sinks, and can be heavily harvested for human consumption.

Observations of perturbations are important for interpreting cycling processes and identifying potential transport mechanisms. Typical observations of stress include:

- Bare soil resulting from erosion, flooding, vehicular use or toxicity;
- Occurrence of contaminant residues;
- Construction and other human induced disturbances;
- Fire;
- Heavy grazing or browsing;
- Unexplained mortality (e.g., standing dead tree boles); and
- Insect and disease damage

An inventory of selected areas adjacent to the site can greatly improve the usefulness of the General Field Survey. In some instances, off-site areas will support the same kinds of ecosystem occurring on-site, but in less disturbed states. Comparison of off-site with on-site ecosystems may provide some indication of the nature and degree of any on-site stresses. It is also important to identify and characterize possible off-site ecosystems that may serve as receptors for air-borne or water-borne contaminants originating on-site. An inventory of productive wildlife habitat in the region surrounding the site can provide a better estimate of potential wildlife usage of on-site areas by mobile species.

5.5 SPECIAL INVESTIGATIONS

At some hazardous waste sites it may be necessary to quantitatively estimate abundance of plant or animal species, or collect samples for chemical analysis. For these objectives, methodologies may have to meet statistical criteria as well as the site-specific health and safety considerations. Methodologies described below are standard, but not necessarily appropriate for all sites because of health and safety constraints. Selection of appropriate methodologies for quantitative studies at a particular site must include the involvement of an ecologist, statistician and health and safety specialist.

5.5.1 Abundance Estimates

Vegetation

Vegetation abundance may be measured in terms of stem density or cover. These measurements are obtained from nested plots, or quadrats; smaller-sized plots, used to sample the lower and middle strata, are contained ("nested") within larger plots used for sampling lower and upper canopy plants. Quadrat and nested sub-plot size may vary with sampling objectives.

Stem density is obtained by counting number of stems per plot. Cover is the percent of ground shaded by all the individuals of one species with the sun directly overhead, and may be estimated by eye to the nearest percent. Where more precise measures of cover of herbaceous and low shrubs is required, the point-frequency and line-intercept methods, respectively, may be considered.

Plots are regularly spaced along transects. Number of transects and number of plots will depend on floral diversity and objectives of program. Sampling adequacy can be based on species-area curves.

Wildlife

Determination of wildlife species occurrence and estimation of density require special techniques depending on species of interest, season, and site features. Standard methods for detecting presence of secretive species include, but are not limited to, the following:

- Live and snap trapping (small mammals);
- Pit trapping (small mammals, reptiles, and amphibians);
- Spot-light surveys (nocturnal species);
- Tape recordings and call counts (amphibians and birds);
- Mist netting (birds and bats);
- Berlese or Tullgren funnels (soil invertebrates); and
- Sweep netting (insects).

Use of most of these techniques is discussed in Schemnitz, (1980). For information on use of funnels for sampling soil invertebrates, consult Bender et al. (1972), and on sweep netting and insect sampling in general, consult Menhinick (1963) and Southwood (1966).

Traps should be set at roughly regular intervals along survey lines located in each of the habitat types to be sampled. Spacing and number of traps will depend on species, territory size, trapping efficiency, program objectives, and investigator's knowledge of species-specific behavior patterns. Spotlight searches and the playing of sound recordings are conducted at regular intervals along survey lines, with consideration for territory size and individual species behavior. Mist nets are located in areas likely to intercept low-flying birds; and likely locales can be selected based on feeding habits and site habitat features.

For most species, standard quantitative measures of wildlife density involve total counts, sample counts or mark-and-recapture. Assumptions and formulae for estimating population densities from these techniques are presented in Wildlife Management Techniques (Schemnitz, 1980), and White et al. (1982). Density estimates are time-specific, as populations of most animals fluctuate greatly from season-to-season and year-to-year.

5.5.2 Collecting Specimens for Chemical Analysis

The objectives of collecting plant and animal specimen for chemical analyses are to (1) identify occurrence of elevated concentrations of potential contaminants, (2) identify gradients of contaminant concentration, and/or (3) quantitatively determine concentrations in particular target species. For the latter two objectives a statistical approach will have to be developed to determine number of samples per tissue type, species, location, etc.

Selection of species for chemical analysis will depend on the program objectives, nature of suspected contaminants, and ecosystems occurring on-site. In most instances, species selected will either be a possible component of the human food chain, or a known bioaccumulator of the contaminant(s) of concern.

In developing a sampling plan and while collecting plant specimens, a number of factors have to be considered which influence concentrations of substances in vegetation. Concentrations may vary with height above ground, distance from plant perimeter, species, and plant tissue (e.g., leaf, root, current year stem, old growth stem and fruit). Many substances are relatively immobile in plants,

tending to accumulate at exterior surfaces where concentrations may be affected by rainfall washing and leaching. Soil factors can greatly influence substance availability for plant uptake and thus tissue concentrations.

After sampling design has been determined, consult with the analytical laboratory for proper containers and storage procedures. For most sampling efforts, zip-lock plastic bags will be adequate. Animal specimen should be stored in refrigerated containers and then frozen until laboratory analysis.

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7.0 ATTACHMENTS

Attachment A - Typical Terrestrial Ecology Field Data Sheet
Attachment B - Site Characterization

ATTACHMENT A

TYPICAL TERRESTRIAL ECOLOGY FIELD DATA SHEET

SITE: _____

INVESTIGATOR: _____ DATE: _____

SAMPLING LOCATE OR TRANSECT: _____

PLOT: _____

REVIEWED: _____

EACH QUANTITATIVE PLANT SAMPLING FORM SHOULD FEATURE ONE OF THE FOLLOWING:

- Upper Canopy (stem diameter > 10 cm): Listing at a minimum each individual by species and DBH (diameter at breast height)
- Lower Canopy (2.5 cm < stem diameter < 10 cm): Listing at a minimum each individual by species and DBH
- Middle Stratum (Height > 50 cm and stem diameter < 2.5 cm and woody vines): Listing at a minimum each species and percent cover.

  Lower Stratum (all herbs; woody spp. < 50 cm tall): Listing at a minimum each species and percent cover.

NOTING:

- Terrain features
- Disturbances
- Wildlife Observations
- Wetlands
- Etcetera

ATTACHMENT B

SITE CHARACTERIZATION

1. **General Information:**

Site ID Number: _____
County: _____
Section: _____
Watershed: _____
Date: _____
Observers: _____ _____
Air Photo Reference: _____
Photographs Taken: _____

2. **Topography and Soils:**

Elevation: _____ Slope Percent: _____
Slope Position: _____ Aspect: _____
Soils: _____

3. **Vegetation (Cover Classes[1]):**

		Tree Stratum	Shrub Stratum	Herb Stratum
Cover (%):				
Cover Type:				
Association:				
Average Height Dominants:				
Average DBH Dominants:				
Species Composition and Abundance:				
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				

ATTACHMENT B
SITE CHARACTERIZATION
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3. **Vegetation (Cover Classes[1]) (CONTINUED):**

		Tree Stratum	Shrub Stratum	Herb Stratum
Cover (%):				
Cover Type:				
Association:				
Average Height Dominants:				
Average DBH Dominants:				
Species Composition and Abundance:				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

(1) Cover classes (midpoints): T < 1% none; 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

4. **Wildlife:**

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- 5.3.2 Transfer of Custody and Shipment
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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

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 all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. 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 and its introduction as evidence. 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 GLOSSARY

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. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

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 your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you 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

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes 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.

5.2 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.

5.2.1 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 Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **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 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just 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 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).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a w[illegible], waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w[illegible] or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and [illegible]vided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la[illegible]tory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

- **Remarks**: Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number**: For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 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 of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and 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.

- 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 because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals 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 follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink 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 G 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 are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black 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 sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

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.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

	PROJECT NAME					NO. OF CONTAINERS							REMARKS
SAMPLERS: *(Signature)*													
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION								

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks:	

ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

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		Prepared Earth Sciences	
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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (>13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	DOT PROPER SHIPPING NAME	HAZARD CLASS	CODE		CONTAINER NUMBERS	PLC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-BN	C	1	✓	
1	55 gal	450 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	250 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-BN	D	3	✓	
1	16-A	12 lbs.	x	Bromine	Corrosive Material	55-BN	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd _____

Shipment Date _____ Manifest No _____

Disposer Work Order _____

Service Order No _____

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

NUS	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well _____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.

4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page _____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.

8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

_____
Field Operations Leader

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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of.

3.0 GLOSSARY

Controlled Document - A consecutively-numbered form released by EPA for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

4.0 RESPONSIBILITIES

Field Operations Leader - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test forms (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 Sample Label

The sample label is a 2- by 4-inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1.

5.1.2 Sample Identification Tag

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

5.1.3 Chain-of-Custody Record Form

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in Zone 1 uses a

slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. Chain-of-custody record forms for Regions I, II, and IV are illustrated in SA-6.1 as well as procedures for filling out forms.

5.1.4 Chain-of-Custody Seal

Attachment B-4 is an example of a custody seal. The Custody seal is a 1- by 3-inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

5.1.5 Bottle Delivery Order (DO) Form

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

5.1.6 Repository Packing List (PL) Form

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

5.1.8 Sample Log Sheet

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

5.1.10 Traffic Report Label

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.

5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations
Attachment B-1 - Sample Label
Attachment B-2 - Sample Identification Tag
Attachment B-3 - Chain-of-Custody Record From, Region III
Attachment B-4 - Chain-of-Custody Seal
Attachment B-5 - CLP Sample Bottle Repository Order Form
Attachment B-6 - Repository Packing List Form
Attachment B-7 - Groundwater Sample Log Sheet Form
Attachment B-8 - Soil Sample Log Sheet Form
Attachment B-9 - Surface Water Sample Log Sheet Form
Attachment B-10 - Container Sample Log Sheet Form
Attachment B-11 - Organics Traffic Report Form
Attachment B-12 - Inorganics Traffic Report Form
Attachment B-13 - Traffic Report Labels
Attachment B-14 - Special Analytical Services (SAS) Packing List
Attachment B-15 - Dioxin Shipment Record Form
Attachment B-16 - Sample Shipping Log
Attachment C-1 - Groundwater Level Measurement Sheet
Attachment C-2 - Pumping Test Data Sheet
Attachment C-3 - Hydraulic Conductivity Testing Data Sheet
Attachment C-4 - Packer Testing Report Form
Attachment C-5 - Summary Log of Boring
Attachment C-6 - Overburden Monitoring Well Construction Sheet
Attachment C-7 - Confining Layer Monitoring Well Construction Sheet
Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet
Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-11 - Test Pit Log Form
Attachment D-1 - Equipment Calibration Log

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP Number	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
B-5	CLP Sample Bottle Repository Form	SA-6.6	Required
B-6	Repository Packing List Form	SA-6.6	Required
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
B-9	Surface Water Sample Log Sheet	SA-6.6	Required
B-10	Container Sample Log Sheet	SA-6.6	Required
B-11	Organics Traffic Report Form	SA-6.6	Controlled
B-12	Inorganics Traffic Report Form	SA-6.6	Controlled
B-13	Traffic Report Labels	SA-6.6	Controlled
B-14	Special Analytical Services (SAS) Packing List	SA-6.6	Required
B-15	Dioxin Shipment Record Form	SA-6.6	Required
B-16	Sample Shipping Log	SA-6.4	Required
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
C-2	Pumping Test Data Sheet	GH-2.3	Required
C-3	Hydaulic Conductivity Testing Data Sheet	GH-2.4	Required
C-4	Packer Testing Report Form	GH-2.2	Required
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
C-7	Confining Layer Monitoring Well Construction Sheet	GH-1.5	Required
C-8	Bedrock (Open Hole) Monitoring Well Construction Sheet	GH-1.5	Required
C-9	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-10	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-11	Test Pit Log	GH-1.8	Required
D-1	Equipment Calibration Log	----	Required

ATTACHMENT B-1

SAMPLE LABEL

NL CORPORATION PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

REQUEST NO. _____

Date of Request: _____

Type of Request:
Routine [ ]
Fast Turnaround [ ] _____
Emergency [ ] _____
(Date/Time request called in)

From (Name): _____
Affiliation: _____
Telephone: _____
AR Signature: _____

TO: I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782/3095

Ship the following items for arrival by: _____ (Date)
(If applicable) Ship to arrive no earlier than: _____ (Date)

Item		Description	No. of Items Per Case	No. of Cases Requested
A	80-oz.	amber glass bottle	6	
B	40-ml	glass vial	72	
C	1-liter	polyethylene bottle	12	
D	120-ml	wide-mouth glass vial	12	
E	1-oz.	wide-mouth glass jar	12	
F	8-oz.	wide-mouth glass jar	12	
G	4-oz.	wide-mouth glass jar	12	
H	1-liter	amber glass bottle	12	
J	32-oz.	wide-mouth glass jar	12	
K	4-liter	amber glass bottle	4	
L	500-ml	polyethylene bottle	24	

Ship To: _____
(Provide _____
street address) _____
Attention: _____
Call before delivery: _____
(Phone No.): _____

DISTRIBUTION: *White-Repository* *Yellow-Requestor* *Pink-SMO*

ATTACHMENT B-6

CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND PACKING LIST

REPOSITORY

I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782-3905

DELIVERY REQUEST NO. _____

Request date: _____

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: _____

DESTINATION (from Delivery Request)

Name: _____

Address: _____

_____

_____

Telephone No: _____

The materials listed below have been shipped as requested.

Date Shipped: _____

Mode of Shipment: _____

Shipment ID No: _____

Signature: _____

Type of Shipment: ___ Complete ___ Partial ___ Partial/Completes Request

Item No.	Description		No. of Cases Shipped	Lot Number(s)	QC Clearance Number(s)
A	80-oz	glass			
B	40-mL	glass			
C	1-L	poly			
D	120-mL	glass			
E	16-oz	glass			
F	8-oz	glass			
G	4-oz	glass			
H	1-L	glass			
J	32-oz	glass			
K	4-L	glass			
L	500-mL	poly			

——AUTHORIZED REQUESTOR USE ONLY——

Sign below and forward the yellow copy to the Sample Management Office (SMO) within 7 days of shipment receipt. Keep the pink copy for your file.

The above request was received by the designee, inspected, and accepted.

Date of Receipt: _____ Requestor Signature: _____

Send yellow copy to: USEPA Sample Management Office
P.O. Box 818
Alexandria, VA 22313

DISTRIBUTION: *White—Shipment Designee*
Blue—Shipping Contractor
Green—SMO
Yellow—Requestor (for return to SMO)
Pink—Requestor
Gold—Repository

ATTACHMENT B-7

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page ____ of ____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

Sample Date & Time:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):

Observations / Notes:

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B-8

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page _____ of _____

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Composite Sample Data		
	Sample	Time	Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			
Type of Sample ☐ Low Concentration ☐ High Concentration ☐ Grab ☐ Composite ☐ Grab - Composite			

Sample Data	
Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)

Analysis:	Observations / Notes

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B-9

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page _____ of _____

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Depth Sampled:				
Sample Date & Time:				
Sampled By:				
Signatures:				

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B-10

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Container Data

Page _____ of _____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other _____ ☐ Bag / Sack ☐ Tank ☐ Other _____	Color _____ Condition _____ Markings _____ Vol. of Contents _____ Other _____

Disposition of Sample	Sample Description	Layer 1	Layer 2	Layer 3
☐ Container Sampled ☐ Container opened but not sampled. Reason _____ Container not opened. Reason _____	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	_____	_____	_____
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
	% of Total Volume	_____	_____	_____
	Other	_____	_____	_____

	Type of Sample	
Monitor Reading:	☐ Low Concentration ☐ High Concentration	☐ Grab ☐ Composite ☐ Grab - Composite
Sample Method:		

		Organic	Inorganic
Sample Date & Time:	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-11

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO: (IF APPLICABLE)

ORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER
NPLD O&M OTHER _____
NON-SUPERFUND—_____PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

TRIPLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	SAMPLE DESCRIPTION Ⓐ (FROM BOX 1) 1 2 3 4 5 6 7	CONCENTRATION Ⓑ (L - LOW/MED H - HIGH (SAS))	RAS ANALYSIS Ⓒ VOLATILE	BASE/NEUT /ACID	PESTICIDE /PCB's		SPECIAL HANDLING Ⓓ	STATION LOCATION Ⓔ

EPA Form 2075-7 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-12

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO: (IF APPLICABLE)

INORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER
NPLD O&M OTHER _____
NON-SUPERFUND—_____ PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	Ⓐ SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7	Ⓑ CONCENTRATION L = LOW M = MED H = HIGH (SAS)	Ⓒ RAS ANALYSIS: TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS): SULFIDE	pH	CONDUCTIVITY	OXIDANTS	Ⓓ SPECIAL HANDLING	Ⓔ STATION LOCATION

EPA Form 2075-6 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-13

TRAFFIC REPORT LABELS

MAB 342

C 6003

AC 865 · Soil/Sediment (VOA)

ATTACHMENT B-14

U.S. ENVIRONMENTAL PROTECTION AGENCY
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: 703/557-2490 - FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICE
PACKING LIST

Sampling Office:	Sampling Date(s):	Ship To:	For Lab Use Only
Sampling Contact: (name)	Date Shipped:		Date Samples Rec'd:
(phone)	Site Name/Code:	Attn:	Received By:

Sample Numbers	Sample Description i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

For Lab Use Only

White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy

ATTACHMENT B-15

USEPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 Alexandria Virginia 22313
FTS 8-557-2490 703 557-2490

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

Site Name	Sampling Office	Ship To	FOR LAB USE ONLY Date Samples Rec'd
City & State	City & State	Date Shipped	Received By
EPA Site No	Sampling Contact (name)		
Latitude	Sampling Date	Transfer To	Date Samples Rec'd
Longitude		Date Shipped	Received By
Tier 1 2 3 4 5 6 7 (circle one)	Data Turnaround 15-Day ___ 30-Day ___		

SAMPLE NUMBERS	MATRIX: SOIL SEDIMENT	MATRIX: OTHER:	DESCRIPTION: FIELD SAMPLE	DESCRIPTION: SAMPLE TO DUPLICATE	DESCRIPTION: SAMPLE TO SPIKE	DESCRIPTION: BLANK	DESCRIPTION: EQUIPMENT RINSEATE	DESCRIPTION: OTHER (BAS ONLY)	ADDL. ANALYSIS: SPECIFY (BAS ONLY)	FOR LAB USE: SAMPLE CONDITION ON RECEIPT

WHITE [illegible] YELLOW [illegible] PINK [illegible] GOLD- [illegible]

ATTACHMENT B-16

page___ of ___ EPA SAMPLE SHIPPING LOG FOR ALL SAMPLES SENT THROUGH THE CONTRACT LAB PROGRAM (12/85 version)

CASE#_____ SAS#_____ SITE NAME:_____

Site Leader:_____ EPA Project Officer:_____

Phone:

SAS REQUEST: (details required)

QC SAMPLE INFO AND/OR COMMENTS	CONC. (low/ med/ high)	SAMPLE PHASE (aq/ sol)	TYPE OF REQUEST org,dio inor, SAS	SAMPLE TRAFFIC REPORT NUMBER	ORGANICS OR INORGANICS		DATA RECEIVED XX out -items not requested						LAB NAME	SAS REQUEST (itemize)	DATE SHIPPED	DATA REC'D
					LAB NAME	DATE SHIPPED	VOA	BNA	PEST	TCDD	METALS	CN				

ATTACHMENT C-1

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____
Project No.: _____
Personnel: _____
Date: _____

LOCATION

Municipality: _____
County: _____
State: _____
Street or Map Location (If Off-Site) _____

WEATHER CONDITIONS

Temperature Range: _____
Precipitation: _____
Barometric Pressure: _____

Equipment No.: _____
Equipment Name: _____
Latest Calibration Date: _____

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT C-3

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO.: .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

kac 3/88

ATTACHMENT C-5

BORING LOG — **NUS CORPORATION**

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA: .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK CONDITIONS	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

ATTACHMENT C-5 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS
More than half of material is LARGER than No. 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>#4 Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel sand mixtures, little or no fines
	GRAVELS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures.
SANDS 50%(+)<#4 Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

FINE GRAINED SOILS
More than half of material is SMALLER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)

Identification procedures on fraction smaller than No. 40 sieve size

	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X - NX (Conventional) Core (~2 1/8" O.D.)
Q - NQ (Wireline) Core (~1 7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▼ 12.6' Initial Level ~/Date & Depth

12/18
▼ 12.6' Stabilized Level ~/Date & Depth

D324901

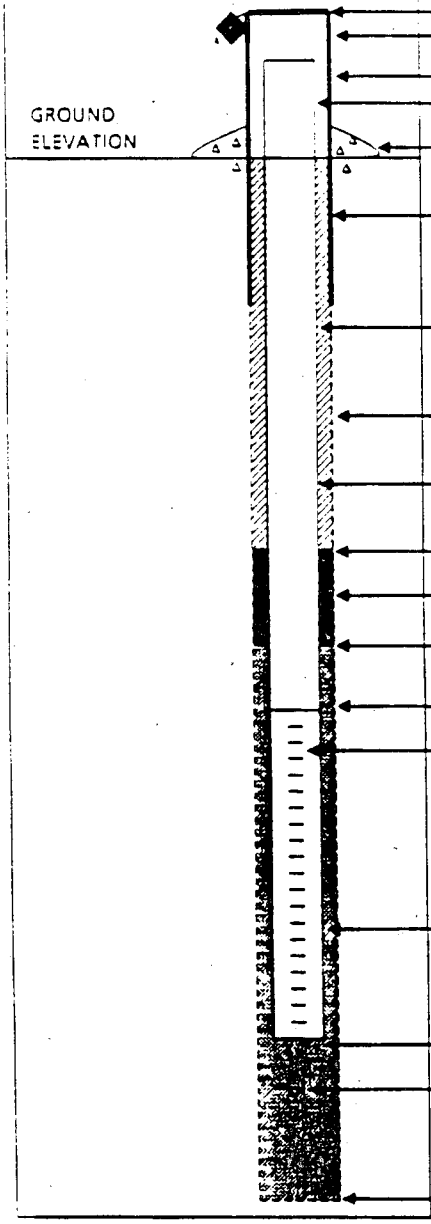
ATTACHMENT C-6

NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-10

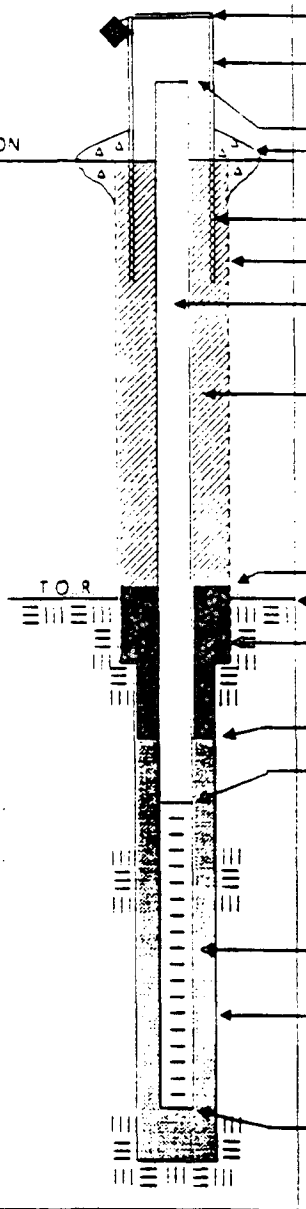
NUS CORPORATION
A Halliburton Company

BORING NO _____

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

ELEVATION / DEPTH TOP OF BEDROCK: _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____

ELEVATION / DEPTH BOTTOM OF HOLE: _____

ATTACHMENT D-1

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): _____

Manufacturer _____ Date Purchased _____

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SF-1.1	Page 1 of 16
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject ONSITE WATER QUALITY TESTING		Approved D. Senovich	

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1.0 PURPOSE

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

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements

2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous 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. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

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 GLOSSARY

3.1 pH MEASUREMENT

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

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

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, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

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.

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.

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

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

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

5.0 GUIDELINES

5.1 MEASUREMENT OF pH

5.1.1 General

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 can also 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, and specific techniques are not described.

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, and the pH meter 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 such cases, use of a pH meter is recommended.

5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity 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 establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that 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.

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.

b. 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.

c. 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.

d. 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).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized 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.

i. 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.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse the electrode(s) with deionized water.

l. Keep the electrode(s) 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, 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.

2. 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, 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

5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

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

5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. 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 may also 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.

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

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. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type 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 at great depths can be performed.

5.3.3 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 or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

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 monitoring discussed herein 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, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest 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 that is 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 the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

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

5.4.4 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:

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.

- The probe shall be conditioned in a water sample for as long a period 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.

- 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).

- 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 placed in wells can be moved up and down.

- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.

- Recalibrate the probe when the membrane is replaced, 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 if a sample was taken.

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

5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

6.0 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.

7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

Temperature (°C)	Specific Conductance (µmhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

1 Data derived from the International Critical Tables 1-3-8.

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	0.016
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

ATTACHMENT B
VARIATION OF DISSOLVED OXYGEN CONCENTRATION
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY
PAGE TWO

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
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
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

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

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SF-1.2	Page 1 of 10
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		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE PRESERVATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4 - Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

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

7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

ATTACHMENT A
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

FT-7.06
REVISION 0

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	Extractables				
	Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	Metals				
	Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	Cyanide				
	Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H_2SO_4 to pH <2	28 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 l	H_2SO_4 to pH <2	28 days
Phenols	--	h.d. polyethylene	1.0 l	H_2SO_4 to pH <2	28 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
SOIL					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	Extractables				
	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
Air					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 1

Parameter No./Name	Container(1)	Preservation(2,3)	Maximum Holding Time(4)
INORGANIC TESTS:			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid(5)	14 days(6)
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
METALS:(7)			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO_3 to pH 2	6 months

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

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Parameter No./Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] HCl to pH 2[9]	14 days
Acrolein and Acrylonitrite	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5[10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
Benzidines[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate Esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines[11,14]	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PCBs[11] Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PESTICIDES TESTS:			
Pesticides[11]	G, Teflon-lined cap	Cool, 4°C, pH 5-9[15]	7 days until extraction, 40 days after extraction
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the [illegible]ne of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at [illegible]° until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation [illegible]ardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis [illegible] still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the [illegible]ic types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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6.0 REFERENCES

1.0 PURPOSE

The purpose of these procedures is to provide general reference information on the control of contaminated materials.

2.0 SCOPE

This procedure describes methods of handling contaminated material during remedial investigation activities. These activities often results in the production or relocation of contaminated materials that must be properly managed to protect the public and the environment as well as to meet legal requirements.

These guidelines are for information only and are not to take precedence over the requirements of project specific plans for the control of contaminated materials.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - Responsible for selecting an appropriate disposal method for contaminated material which may be generated during RI activities.

Field Operations Leader - Responsible for carrying out the requirements established in the Field Operation Plan and overall management of field activities.

5.0 PROCEDURES

5.1 OVERVIEW

For the purposes of these procedures, contaminated materials are defined as any byproducts of a field investigation that are suspected or known to be contaminated with hazardous substances. These byproducts include such materials as decontamination solutions, disposable equipment, drilling muds, well-development fluids, and spill-contaminated materials.

The procedures for obtaining permits for investigations of sites containing hazardous substances are not clearly defined at present. In the absence of a clear directive to the contrary by the EPA and the states, it must be assumed that hazardous wastes generated during investigations will require compliance with Federal agency requirements for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. This procedure will exclusively describe the technical methods used to control contaminated materials.

The work plan for a site investigation must include a description of control procedures for contaminated materials. This planning strategy would assess the type of contamination, estimate the amounts that would be produced, describe containment equipment and procedures, and delineate storage or disposal methods. As a general policy, it is wise to select investigation methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials are expensive and dangerous. Until sample analysis is complete, it is assumed that all produced materials suspected of contamination from hazardous chemicals will always require containment.

5.2 SOURCES OF CONTAMINATED MATERIALS AND CONTAINMENT METHODS

5.2.1 Decontamination Solutions

All decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized rinse solutions such as those recommended for the personnel decontamination station are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. Larger equipment such as backhoes and tractors should be decontaminated in an area provided with an impermeable liner and a liquid collection system. A decontamination area for large equipment could consist of a bermed concrete pad with a floor drain leading to a buried holding tank.

5.2.2 Disposal Equipment

Disposable equipment that could be contaminated during a site investigation typically includes rubber gloves, boots, broken sample containers, and laboratory tissues. These items are small and can easily be contained in 55-gallon drums with lids. These containers should be closed at the end of each work day and upon project completion to provide secure containment.

5.2.3 Drilling Muds and Well-Development Fluids

Drilling muds and well-development fluids are materials used in groundwater monitoring well installations. Their proper use could results in the surface accumulation of contaminated liquids and muds that require containment. Often monitoring wells are placed off the site to determine if hazardous chemicals have migrated below ground. These offsite wells require especially careful management since they threaten contamination of offsite property.

The volumes of drilling muds and well-development fluids used depend on well diameter and depth, groundwater characteristics, and geologic formations. There are no simple mathematical formulas available for accurately predicting these volumes. It is best to rely on the experience of reputable well drillers familiar with local conditions and the well installation techniques selected. These individuals should be able to estimate the sizes of containment structures required. Since guesswork is involved, one should always be prepared so halt drilling or other well-development operations if more containment capacity is needed.

Drilling fluid (mud) is mixed and stored in a container commonly referred to as a mud pit. This mud pit consists of a suction section from which drilling fluid is withdrawn and pumped through hoses and down the drill pipe to the bit and back up the hole to the settling section of the mud pit. In the settling section, the fluid velocity is reduced by a screen and several flow-restriction devices, thereby allowing the well cuttings to settle out of the fluid.

The mud pit may be either portable above-ground tanks commonly made of steel which is preferred or stationary in-ground pits (Figure 5-1). The above-ground tanks have a major advantage over the in-ground pits because the tanks isolate the natural soils from the contaminated fluids within the drilling system. The tanks are also portable and can usually be cleaned easily.

As the well is drilled, the sediments that accumulate in the settling section must be removed. This is best done by shoveling them into drums or other similar containers. When the drilling is complete, the contents of the above-ground tank are likewise shoveled or pumped into drums, and the tank is cleaned and available for use.

If in-ground pits are used, they should not extend into the natural water table. They should also be lined with a bentonite-cement mixture followed by a layer of flexible impermeable material such as plastic sheeting. Of course, to maintain its impermeable seal, the material used would have to be nonreactive with the wastes. An advantage of the in-ground pits is that well cuttings do not necessarily have to be removed periodically during drilling because the pit can be made deep enough to contain them. Depending on site conditions, the in-ground pit may have to be totally excavated and refilled with uncontaminated natural soils when the drilling operation is complete.

When the above-ground tank or the in-ground pit is used, a reserve tank or pit should be located at the site as a backup system for leaks, spills, and overflows. In either case, surface drainage should be such that any excess fluid could be controlled within the immediate area of the drill site.

The containment procedure for well-development fluids is similar to that for drilling fluids. The volume and weight of contaminated fluid will be determined by the method of development. When a new well is bailed to produce clear water, substantially less volume and weight of fluid result than when backwashing or high-velocity jetting is used.

5.2.4 Spill-Contaminated Materials

A spill is always possible when a site investigation involves opening and moving containers of liquids. Contaminated sorbents and soils resulting from spills will have to be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable structures. In some cases on-site containment may not be feasible, and immediate transport to an approved disposal site will be required.

5.3 DISPOSAL OF CONTAMINATED MATERIALS

Actual disposal techniques for contaminated materials are the same as those for any hazardous substance--incineration, landfilling, treatment, and so on. The problem centers around the assignment of responsibility for disposal. The responsibility must be determined and agreed upon by all involved parties before the field work starts. If the site owner or manager was involved in activities that precipitated the investigation, it seems reasonable to encourage his acceptance of the disposal obligation. In instances where a responsible party cannot be identified, this responsibility may fall on the public agency or private organization investigating the site.

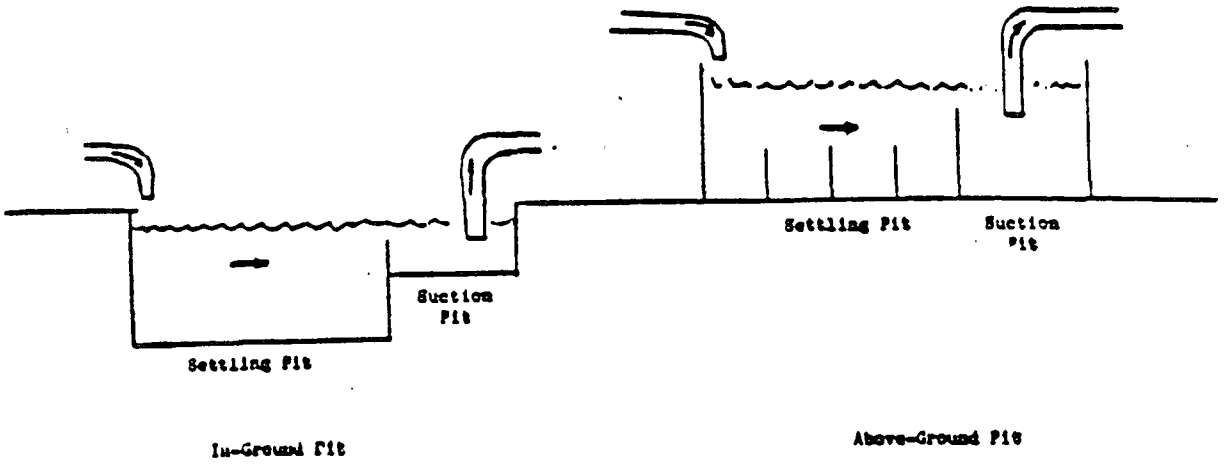
Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of suitable onsite disposal structure is expected, contaminated materials generated during the investigation should be stored at the site for disposal with other site materials. In this case, the initial containment structures should be evaluated for use as long-term storage structures. Also, other site conditions such as drainage control, security, and soil type must be considered so that proper storage is provided. If onsite storage is expected, then the limited containment structures should be designed for that purpose.

6.0 REFERENCES

NUS Corporation: Standard Operating Procedure No. 4.33, Control of Contaminated Material

FIGURE 5-1

TWO TYPES OF MUD PITS USED IN WELL DRILLING



Source: Ecology and Environment, Inc., Technical Methods for Investigating Sites Containing Hazardous Substances, Draft Technical Monographs, prepared for the U.S. Environmental Protection Agency, June 1981.

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1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

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

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid factions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

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* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

** If sampling for pesticides, PCBs, or fuels.

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2 FIELD ANALYTICAL EQUIPMENT

5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.