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COMPREHENSIVE SITE ASSESSMENT WORKPLAN

UNDERGROUND FUEL INVESTIGATION
CAMP GEIGER FUEL FARM
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

July 25, 1991

Law Engineering Job No. J47591-6014

Law Engineering, Inc.
Raleigh, North Carolina

LAW ENGINEERING

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LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL
& CONSTRUCTION MATERIALS
CONSULTANTS

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Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia 23511-6287

Subject: **UNDERGROUND FUEL INVESTIGATION, COMPREHENSIVE SITE ASSESSMENT WORKPLANS**
CAMP GEIGER FUEL FARM
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT NO. N62470-90-D-7625
LAW ENGINEERING JOB NO. J47590-6014

Dear Mr. Seamans:

Please find enclosed two copies of the above referenced Workplan document. This document covers those tasks designed to identify and delineate subsurface contamination and estimate its direction and rate or movement at the Camp Geiger Fuel Farm.

Please review the enclosed document and contact me regarding any questions or comments. Also note that we plan to begin field activities on August 5, 1991.

Law Engineering appreciates the opportunity to continue to provide services to you and LANTDIV on your environmental projects.

I look forward to hearing from you soon.

Sincerely,

LAW ENGINEERING, INC.

W. Douglass Dixon, P.E.
Senior Engineer/Project Manager

J. Allen Kibler, Jr., P.G.
Principal Geologist
Licensed, North Carolina 1077

NORTH CAROLINA LICENSED SEAL 1077 GEOLOGIST J. ALLEN KIBLER, JR.

WDD/alc

ENCLOSURES

cc: Stephany Del Re' Johnson - Camp Lejeune w/enclosures
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1.0 INTRODUCTION

The purpose of this Comprehensive Site Assessment Workplan (Workplan) is to serve as a guidance document and procedural manual for performing tasks to aid in determining the magnitude and extent of soil and ground-water contamination; identifying possible free product accumulation; and assessing potential exposure to possible subsurface contaminants at the Camp Geiger Fuel Farm. The location of the Fuel Farm within the Marine Corps Base is shown in Drawing 1.1.

This Workplan was prepared in accordance with the Scope of Work (SOW) developed by the Naval Facilities Engineering Command and requirements listed as Tasks I through VIII of the document entitled "Comprehensive Site Assessments at LUST Sites: Basic Tasks and Minimal Elements" prepared by the Groundwater Section of the North Carolina Department of Environment, Health and Natural Resources (NCDEHNR). Significant information and data has already been compiled during previous investigations with which to address Tasks IX and X listed in the State document. The objective of the Comprehensive Site Assessment is to provide sufficient data to meet the requirements of Sections 280.63 and 280.65 of 40 CFR Part 280, Federal Technical Standards for Underground Storage Tanks and Sections .0704 and .0706 of Title 15A, Chapter 2, Subchapter 2N, North Carolina Criteria and Standards Applicable to Underground Storage Tanks.

2.0 SITE CHARACTERIZATION

2.1 Regional Hydrogeology

In the Camp Lejeune area, sediments deposited in marine or near-marine environments are about 1,500 feet thick and overlie igneous and metamorphic basement rocks. The aquifers of the Camp Lejeune area are the surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. They are separated by less permeable clay and silt beds (confining units) that serve to impede the flow of ground water between the aquifers (Harned, 1989).

The surficial aquifer is a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This unit is not used for water supply on the Base. The principal water-supply aquifer for the Base is the series of sand and limestone beds that occur between 50 and 300 feet below land surface. This series of sediments generally is known as the Castle Hayne aquifer. The Castle Hayne aquifer is about 150 to 350 feet thick in the area and is the most productive aquifer in North Carolina. It is a critical water-supply source, not only for Camp Lejeune but also for the southern coast and east-central Coastal Plain of North Carolina (Harned, 1989).

Camp Lejeune is situated in an area where the Castle Hayne aquifer contains freshwater, although the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals from the aquifer. The aquifers that lie below the Castle Hayne consist of a thick sequence of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the Camp Lejeune area (Harned, 1989).

Water levels in wells tapping the surficial aquifer vary seasonally. The surficial aquifer receives more recharge in the winter than in the summer when much of the water being evaporated or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter months and lowest in summer or early fall. The hydraulic head in a confined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than that in an unconfined aquifer. Some seasonal variation also is common in the water levels of the Castle Hayne aquifer, but the changes tend to be slower and over a smaller range than for water-table wells (Harned, 1989).

2.2 Site Hydrology/Hydrogeology

The following information regarding site hydrology/hydrogeology contained in this section is taken directly from the report entitled Draft Field Investigation/Focused Feasibility Study, Camp Geiger Fuel Spill Site, prepared by NUS Corporation and dated December 1990.

Surface waters and runoff from the site generally flow in an easterly direction into Brinson Creek. One drainage way originates in the northwestern corner of the site and is an open ditch that routes stormwater runoff from the Base into Brinson Creek. Prior to its confluence with Brinson Creek, the ditch merges with another storm water runoff ditch that originates in the southwestern portion of the site and passes approximately 50 feet south of the central project study area. Another drainage ditch originates in the western portion of the site and terminates near the central part of the study area. This ditch no longer flows, but currently has ponded water in it due to recent digging at the site by Base personnel. Brinson Creek flows in a southeasterly direction approximately 200 feet east of the site and flows into the New River approximately 3/4 of a mile downstream. Brinson Creek and the two storm water runoff ditches are strongly influenced by the tides (NUS, 1990).

The shallow subsurface geology of the study area consists of a surficial layer of unconsolidated fine-grained sand with trace amounts of silt and clay, which is underlain by a layer of fine-grained sand with thin, discontinuous clay and gravel lenses. Soil density ranges from very loose to medium dense (NUS, 1990).

The depth of the water table at the Fuel Farm study area ranges from one to eight feet below land surface (BLS). The water table reportedly fluctuates approximately 1 foot with tidal advances, rising to near the ground surface in the low lying portions of the study area during high tide. Based on the potentiometric surface data, groundwater flow direction across the site is generally to the northeast toward Brinson Creek. The flow direction is consistent with the expected hydraulic gradient, given the existing topography and local surface drainage. Based on this information, as well as the general topography west of Brinson Creek, it is likely that ground-water discharges into Brinson Creek from both the site and the surrounding areas west of the creek (NUS, 1990).

3.0 PREVIOUS INVESTIGATIONS

Previous investigations related to contamination of natural resources at the Camp Geiger Fuel Farm were conducted by several environmental companies in 1984, 1986 and 1990. Results of the investigations indicate that soil and ground-water contamination by petroleum-fuel related hydrocarbons is present in the vicinity of and downgradient from the Fuel Farm. During the 1986 and 1990 investigations, a total of seven ground-water monitoring wells were installed in the vicinity of the Fuel Farm. The locations of these wells are exhibited in Drawing 3.1.

4.0 UNDERGROUND FUEL LINE TESTING

On May 29, 1991, representatives of Law Engineering performed a reconnaissance of the fuel storage and distribution system at Camp Geiger. Information regarding current operations of the fuel farm was also obtained through discussions with Mr. Anthony Koonce, civilian-in-charge of fuel dispensing at the Camp Geiger Fuel Farm and Mr. Don Finney, Assistant, Officer-In-Charge of Direct Support Stock Control at Camp Lejeune. The following active system components were observed during the site visit:

Aboveground Storage Tanks

- One 10,000-gallon capacity diesel fuel
- One 10,000-gallon capacity unleaded gasoline
- One 15,000-gallon capacity unleaded gasoline
- One 15,000-gallon capacity diesel fuel
- One 15,000-gallon capacity kerosene

Underground Fuel Transmission Lines

- Unleaded gasoline
  - from unloading to pump (approximately 40 feet)
  - from pump to vehicle dispensers (approximately 120 feet)

- Diesel Fuel
  - from unloading to pump (approximately 40 feet)
  - from pump to vehicle dispenser (approximately 105 feet)
  - from pump to overhead tanker dispenser (approximately 80 feet)

- Kerosene
  - from unloading to pump (approximately 110 feet)
  - from pump to overhead tanker dispenser (approximately 130 feet)

In an effort to determine if the underground fuel transmission lines are contributing to subsurface contamination in the vicinity of the Fuel Farm, the above-referenced lines will be tested using the Tracer Tight tightness testing method. Briefly, the Tracer Tight method will be performed as follows:

- Inoculate each tank system with a tracer (bromotrifluoromethane) by depositing the tracer into each fill port immediately prior to a scheduled delivery.

- Allow sufficient time (normally 21 days) for the tracer to be distributed throughout each tank system.

- Place probes in the subsurface along the underground lines at approximately 25-foot intervals.

- Extract a soil gas sample from each probe and analyze the sample for presence of the tracer and total volatile petroleum hydrocarbons by gas chromatography; analysis will be conducted in the field.

A more detailed description of the Tracer Tight Standard Operating Procedures is contained in Appendix A. Upon completion of the line testing and review of the test data, the Navy will be verbally notified of the results. Written test results will be included in the Comprehensive Site Assessment report and will include leak status (pass or fail); location and relative severity of detected leaks; and a scale drawing showing piping location, soil gas probe locations, fuel dispensers and other pertinent site features.

5.0 HYDROGEOLOGIC FIELD INVESTIGATION

The major objectives of the hydrogeologic field investigation and ground-water assessment program are to (1) identify sources(s) of subsurface petroleum fuel contamination at the Camp Geiger Fuel Farm; (2) define the approximate lateral and vertical extent of free product accumulation (if any) and dissolved-phase ground-water contamination resulting from possible discharge of petroleum fuels at the Fuel Farm; and (3) determine the approximate direction and rate of migration of ground-water contaminant constituents at the project site. In order to accomplish these objectives in a systematic and cost-effective manner, the investigation will be carried out in a two-phase approach. Field activities will be performed in adherence to procedures and guidelines contained in the project Health and Safety Plan (Appendix B).

Phase I will involve the acquisition of approximately twenty ground-water samples via Hydropunch sampling technique and the drilling of approximately six soil borings in order to accomplish the following:

- Obtain lithological data with which to define near-surface geologic conditions;
- Determine whether contaminant constituents are present in the unsaturated zone areas of the soil borings. Several borings will be advanced in the immediate vicinity of a suspected underground storage tank located approximately 150 feet west of the fuel storage area;
- Develop a preliminary evaluation of the lateral extent of dissolved-phase ground-water contamination;
- Determine the need for and optimal location of monitoring wells to define the lateral extent of potential free product accumulation and dissolved-phase contamination.

Phase II investigatory work will be designed based on the results obtained during Phase I activities and will include installation of up to twenty monitoring well "pairs". The wells will provide for:

- Acquisition of data necessary to further define the lithology beneath the project site;
- Acquisition of data necessary to develop a water table contour map and determine the direction of ground-water flow across the project site;
- Acquisition of data to ascertain the lateral extent and approximate thickness of the free product plume, if present;

- Acquisition of data necessary to establish the approximate geometric dimensions (vertical and lateral) of the dissolved-phase contaminant plume(s), if present; and

- Reproducible sampling points in the upper and lower portions of the surficial aquifer.

5.1 Hydropunch Sampling and Soil Test Borings

5.1.1 Hydropunch Sampling

Proposed Hydropunch sampling locations are shown on Drawing 5.1. Collection of these ground-water samples will be accomplished by the Hydropunch ground-water sampling system being driven through the unsaturated zone into the water-bearing zone. The Hydropunch will then be opened to allow ground water to enter into the sample chamber. Samples will be collected by lowering a small-diameter, Teflon bailer into the sample chamber. The samples will analyzed for purgeable aromatics using EPA Method 602. Sample identification and chain-of-custody procedures, as outlined in Sections 5.5.3 and 5.5.7 of this Workplan, will be followed.

The locations of these samples were selected based on suspected contaminant source locations and the anticipated direction of ground-water flow. The sampling grid is based on approximate 150-foot centers and is intended to provide complete coverage of the possible spatial extent of the dissolved-phase plume(s). Where petroleum contamination is detected, the information from the Hydropunch samples will be used to locate monitoring well "pairs" in the appropriate lateral directions.

5.1.2 Soil Test Borings

Locations of proposed soil borings to be drilled during Phase I of the investigation will be determined based on data gathered during the underground fuel line testing and verification of the actual location of the suspected underground storage tank. The network consists of six borings advanced to a depth of twelve to fifteen feet below land surface (BLS). Locations will also be subject to subsurface utility and fuel transmission line clearance. This network is intended to provide a determination as to the presence or absence of petroleum contamination in the immediate vicinity of suspected leak locations. If petroleum contamination is detected, the information from the borings will be used to assist with location of monitoring well "pairs".

Soil samples for general site characterization will be obtained from the six soil test borings at the following depths: 0.0-ft to 1.5 ft; 1.5-ft to 3.0 ft; 3.0-ft to 4.5-ft; and 5.0-ft centers thereafter. The soil samples will be obtained using a split spoon sampler driven in accordance with ASTM D-1586. Soil samples will be identified in the field by an engineer or geologist trained in using visual/manual techniques as described in ASTM D-2487 and D-2488. The soils will be classified in accordance with the Unified Soils Classification System and a test boring record of each borehole will be produced. A sample test boring record used for final presentation of standard test boring data is shown as Drawing 5.2.

Samples for chemical analysis will be collected and analyzed in accordance with procedures outlined in Section 5.3 of this Workplan.

5.2 Monitoring Well Network

5.2.1 Well Locations

The locations of the proposed monitoring well "pairs" will be selected based on laboratory analytical results of the Hydropunch samples along with observations of topography, local discharge features and estimated ground-water flow direction.

5.2.2 Well Design and Construction

All "paired" monitoring wells will be constructed of 2-inch diameter PVC, machine slotted wells screens and 2-inch diameter, Schedule 40 PVC riser pipe. Piping will be flush jointed and threaded, and wells will be constructed without the use of glue. Screen slot widths will be 0.010 inches. Sand packs will be constructed of washed silica Torpedo sand (ASTM C190).

The well "pairs" will be constructed to include two separate wells in each borehole. The deeper well will be constructed with a 3-foot section of well screen situated approximately 12 to 15 feet below the bottom of the paired shallow well. The shallow well will be constructed with a 10-foot section of well screen to extend above and below the water table. A bentonite seal will be placed above the deeper well screen to prevent downward vertical migration of contaminants along the annular space. Typical monitoring well construction details are shown on Drawings 5.3 (developed areas) and 5.4 (undeveloped areas).

The well drilling will be performed with drilling rigs fully equipped for dry auger drilling. All wells will be installed by a qualified driller registered in the State of North Carolina and well installation will be supervised in the field by a staff geologist or engineer specializing in subsurface investigation. No grease or oil will be used on drill pipe joints. However, Teflon tape, vegetable oil, or phosphate-free laboratory detergent such as Liquinox will be used for lubrication, if required. A registered professional engineer specializing in subsurface contaminant investigations will provide overall technical oversight of well installation practices.

5.2.3 Detailed Well Installation Procedures

All PVC screen and riser used in well construction will be pre-cleaned and packaged by the manufacturer. All well casing and screens will be transported and stored at the site in original packaging. Personnel handling these items will not handle tools or drilling equipment while installing the well. Clean, new disposable latex rubber gloves will be worn when handling well screens or casing. The wells will be installed as follows:

- Boreholes will be advanced with 3.75-inch I.D. hollow stem auger drilling technique to a depth of approximately 28 feet below land surface (BLS).

- Samples for chemical analysis will be collected via split spoon sampling in accordance with procedures outlined in Sections 5.12 and 5.3 of this Workplan.

- At two well "pair" locations, soil samples from the upper and lower screen elevations will be collected and analyzed for grain size distribution in order to obtain additional information regarding the hydraulic and physical properties of the aquifer material.

- The augers will be removed from the borehole.

- The borehole will be enlarged with 10.25-inch I.D. hollow stem auger drilling technique to a depth of approximately 28 feet BLS.

- The desired sections of 2-inch well screen and riser pipe for the "deep" well will be assembled and lowered to the bottom of the augers.

- The lengths of all screen and riser casing sections and bottom plugs will be measured and recorded.

- Washed silica filter sand will be poured into the augers to construct a continuous filter pack within the augers which will extend from approximately one foot below the bottom of the well screen to a maximum of two feet above the slotted section. The depth to the sand pack will be frequently measured through the augers using a decontaminated weight attached to a fiberglass measuring tape while "pulling" the augers without rotating them to maintain the sand inside the augers as the filter pack is constructed.

- A 3-foot-thick bentonite seal will be emplaced above the sand filter pack by pouring bentonite pellets into the augers in the manner described above. Distilled water will be added to the annular space at ten-minute intervals to aid in the hydration of the bentonite seal. The bentonite seal will be allowed to hydrate in accordance with manufacturer's recommendations prior to emplacement of the "shallow" monitoring well.

- The desired sections of 2-inch well screen and riser pipe for the "shallow" well will be assembled and lowered to within one foot of the bentonite seal.

- Washed silica filter sand will be poured through the augers while the augers are pulled back incrementally to construct a continuous filter pack within the augers which will extend from approximately one foot below the bottom of the "shallow" well screen to a minimum of two feet above the slotted section. The depth to the sand pack will be frequently measured through the augers using a decontaminated weight attached to a fiberglass measuring tape to maintain the sand inside the augers as the filter pack is constructed.

- A one-foot-thick bentonite seal will be constructed above the sand filter pack by pouring bentonite pellets into the annular space in the manner described above. Distilled water will be added to the borehole at ten minute intervals to aid in the hydration of the bentonite seal. The bentonite seal will be allowed to hydrate prior to placement of grout.

- The annular space above the bentonite seal will be tremie grouted from bottom to within approximately 3 feet of land surface with neat cement grout.

- After allowing the grout to set, the concrete pad and well bore cover will be installed to complete the installation.

- In developed areas, each well will be protected with three Schedule 40 steel pipes, 3-inch I.D., imbedded in a minimum of 2.5-feet of 3,000 psi concrete. A security pipe with a hinged locking cap will be installed over the well casings having an embedment depth of 2.5 feet into the grout. The security pipes will extend a minimum 2.5 feet and maximum 4.0 feet above the ground surface. The security pipes will be filled with concrete and painted day-glow yellow or an equivalent. A concrete apron constructed of 3,000 psi concrete and measuring 5-foot by 5-foot by 0.5 foot will be constructed around each well located in developed areas (Drawing No. 5.3).

- In undeveloped areas, the annular space between the casing and the borehole will be grouted to a depth of at least 2.5 feet and finished with a concrete collar and pad. The collar and pad will be constructed of 3,000 psi concrete and will be formed to extend approximately 6 inches above land surface (Drawing 5.4).

- Final well construction details will be provided on the forms included as Drawing 5.5.

5.2.4 Well Development

Well development will be performed no sooner than 48 hours after grouting is completed. Wells will be developed by continuous low yield pumping and the pumps will be set at bottom of each well. As the wells are developed, ground-water temperature, pH, and specific conductance will be monitored as indicator parameters. The turbidity of the development water will be noted visually and recorded. Well development will continue until indicator parameters are stable (<10% change between 4 consecutive measurements) and the water is relatively free of suspended sediments.

5.2.5 Drilling and Well Installation Equipment Decontamination

Equipment used for drilling and monitoring well installation and development will be cleaned and handled in accordance with the following guidelines:

- Drill rigs and all support equipment will be cleaned of excess grease, oils and caked-on soil prior to arrival at the site. Equipment which leaks fuel, coolant, or lubricants will not be used on site.

- Down-hole tools and equipment will be cleaned with high pressure steam cleaning equipment using potable water from the Camp Geiger Marine Corps Base water supply system after arrival and prior to commencement of the work; at completion of the work; and between boring and well locations. A potable water supply sampled collected from the spigot at the Fuel Farm was analyzed for and shown to be free of purgeable aromatic hydrocarbons.

- Steam cleaning of drilling equipment will be performed at the site on the truck unloading ramp located at Tank Farm.

- Equipment such as pumps and pump lines will be flushed thoroughly with potable water prior to use.

5.2.6 Disposal of Borehole Cuttings and Development Water

Borehole cuttings and well development water will be field tested for presence of volatile organic compounds using a photoionization detector (PID). Borehole cuttings which do not exhibit evidence of contamination will be spread on land surface in the immediate vicinity of the wellhead. Borehole cuttings which exhibit evidence of contamination will be removed from the drill site, transported to a deserted concrete roadway located northwest of the project site and encapsulated with plastic to prevent runoff. Ultimate disposal of the material will be based on analytical results and/or regulatory consultation to ascertain whether the waste material is designated hazardous or non-hazardous. Disposition of this material is not within the scope of this Workplan.

Development water which does not contain evidence of contamination will be discharged to land surface in the vicinity of the wellhead. Development water which exhibits evidence of contamination will be containerized and discharged to a sanitary sewer access located at the Fuel Farm. All free product collected during well development will be containerized for subsequent pickup and disposition by Marine Corps personnel.

5.3 Borehole Sampling for Chemical Testing

Sampling activities will be conducted during drilling of boreholes in order to ascertain the presence of petroleum fuel related compounds in the unsaturated zone and identify areas of suspected near-surface releases of petroleum fuels.

During drilling of each soil boring, soil samples will be retrieved via split spoon sampler as described in Section 5.1.2. Two portions of each sample will be removed from the sampling device and placed in pre-labeled, airtight, plastic "twin" bags. After several minutes, the gas contained in the "headspace" or void area within one of the twin bags will be tested with a photoionization detector (PID).

The duplicates of the two samples from each borehole exhibiting the highest headspace readings will be submitted to the laboratory for analysis. However, sampling locations and quantities may be adjusted in the field to provide adequate definition of the contamination. Soil samples collected for chemical analysis will be analyzed for the following parameters using the listed methods:

Parameter	Method
Flash Point (10 samples only)	SW846/1010
Total Petroleum Hydrocarbons	SW846/5030/3550
TCLP Metals (Lead only)	Extraction 1311

5.4 Surveying

Horizontal and vertical locations of all wellheads, soil borings and Hydropunch sampling points will be surveyed in reference to mean sea level (if a data point is within reasonable distance of the Fuel Farm) or an assumed datum at the site. Surveys will be supervised by a registered land surveyor.

5.5 Ground-Water Sampling

The ground water sampling program has been developed to determine the magnitude and extent of free product accumulation and dissolved-phase ground-water contamination that may be present as a result of petroleum fuel releases at the Fuel Farm. The sampling program will consist of purging and sampling all existing and newly-constructed monitoring wells. Purging and sampling will proceed from the least contaminated areas to the highest contaminated areas based on review of Hydropunch sampling data and field conditions observed during Phase I activities. The sampling program will include collection of samples for laboratory analysis; field analysis of pH, specific conductance, and temperature; ground-water level measurements; and product thickness measurements.

The Law Engineering Monitoring Well Sampling and Field Data Worksheet (Drawing 5.6) will be used to record all measurements made during well purging and sampling. This form was designed to be used as a checklist and as documentation for all ground-water sampling activities for an individual well.

5.5.1 Ground-Water Level and Free Product Thickness Measurement

Prior to well purging and sampling, water level and free product thickness measurements will be performed in all monitoring wells at the site no sooner than 48 hours after completion of well development activities. Measurements will be performed in all monitoring wells at the site on the same day to provide a complete set of comparable measurements. These measurements will be used to calculate hydraulic gradients, determine direction of ground-water flow at the site, and estimate thickness of free product (if present) in the subsurface beneath the Fuel Farm area.

Water level and free product thickness measurements will be performed using an electronic interface probe. The liquid levels will be measured by slowly lowering the instrument probe into the well. When the probe reaches the water or free product surface, the circuit is completed and a buzzer is activated. A constant buzzing indicates free product while an intermittent buzzing indicates water. The distance from the surveyed marker on the top of the well casing to either the water or free product level is then measured and recorded. If free product is present, the thickness will be measured to the nearest 0.01 foot. Water levels will be measured to the nearest 0.01 foot. The instrument probe will be decontaminated between wells by detergent wash and distilled water rinse.

A complete set of water level measurements taken on the same day will be recorded on the Water Elevation Worksheet (Drawing 5.7). When the well cap is removed, a photoionization detector will be used to test the air space within the top of the well casing. The level of gross volatile organics detected (ppm) and odors noted will also be recorded.

5.5.2 Well Purging

Each well will be purged prior to sample collection to remove stagnant water from the well and well bore in an effort to collect samples that are representative of the water quality in the formation surrounding each well. For wells that recover quickly, three standing well volumes of water will be removed. Specific conductance, pH, and water temperature will be measured periodically during well purging. Wells that can be purged to dryness with less than three well volumes being removed will be sampled as soon as the well has recovered enough to yield sufficient volume for a sample. All purge water removed from the wells during purging procedures will be disposed in accordance with procedures for disposal of development water as described in Section 5.2.6 of this Workplan.

Well purging will be accomplished using decontaminated, clear Teflon bailers. New nylon rope will be used at each monitoring well location. Care will be taken to prevent contact between the rope and the ground during well purging and sample collection. Purging techniques will be performed in accordance with recommended practices described in the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities (Solid Waste Section, 1987). The volume of water to be purged is calculated using the following equation:

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

where:

$\pi = 3.14159$

r = *Radius of well casing*

h = *Height of water column in well (total well depth - depth to ground water prior to purging)*

V = *Volume of water in well (standing well volume)*

Minimum purge volume = $V \times 3$

5.5.3 Sample Identification

Prior to collecting each sample, sample bottles will be labeled with the following information:

- Date and time of sample collection;
- Project identification number;
- Sample location number;
- Initials of person who collected sample;
- Type of preservative added to sample; and
- Parameter(s) or parameter group to be analyzed.

Additional specific information, such as sampling interval, may be added. The sample location number on the label will correspond to the sample location numbers assigned on the field site map.

5.5.4 Sample Collection

Samples will be collected immediately upon purging of the well in accordance with the following procedures:

- Chemical preservatives, if applicable, will be added to sample bottles by the laboratory.

- Sample bottles will be labeled prior to sample collection.

- Sample bottles will be filled directly from the Teflon bailer. Volatile organic samples will be collected first.

- The pH, temperature, and specific conductance of the sample will be measured and recorded. These measurements will be taken from a sample deposited in a separate container. Visual characteristics of the sample, including insoluble materials, will be recorded.

- Caps will be secured on bottles.

- Volatile organic sample containers will be placed in plastic bags and the bags sealed.

- Documentation, including Chain-Of-Custody Record and laboratory analytical request form, will be completed for all samples.

- Samples will be packed in coolers with "bubble wrap" and ice packs for shipment.

- Chain-Of-Custody Record and analytical request form will be placed inside cooler sealed with security tape.

- Samples will be shipped via overnight express to the analytical laboratory within 24 hours following collection.

- Laboratory will be advised of each sample shipment.

5.5.5 Sample Analysis

Ground-water samples collected from each monitoring well will be analyzed for the following parameters using the listed methods:

Parameter	Method
Purgeable Halocarbons	EPA Method 601
Purgeable Aromatics (including MTBE)	EPA Method 602
Polynuclear Aromatic Hydrocarbons (5 samples only)	EPA Method 610
Lead-total	EPA Method 239.2

As part of our quality control program, one trip blank with each sample shipment and five equipment rinse blanks will be analyzed for purgeable aromatics via EPA Method 602. Two duplicate samples will be analyzed for all parameters listed above.

5.5.6 Ground-Water Sample Collection Equipment Decontamination

Teflon bailers used for ground-water sampling are routinely decontaminated and stored as follows:

- Washed with phosphate-free detergent and tap water using a brush to remove any particulate matter or surface film.

- Rinsed thoroughly with distilled water.

- Rinsed thoroughly with a 10% nitric acid mixture.

- Rinsed thoroughly with distilled water.

- Rinsed with isopropanol.

- Allowed to air dry.

- Wrapped completely with aluminum foil and sealed in airtight plastic bags.

5.5.7 Chain of Custody (COC)

Procedures will be followed to establish documentation to trace sample possession from the time of collection until completion of analysis. In order to accomplish this objective, as few people as possible will handle sample(s) and the sampler will be responsible for the care and custody of the samples until they are delivered to the laboratory or dispatched for shipment. An accurate record of sample collection, transport and analysis will be maintained and documented. COC procedures will be instituted and followed throughout the investigation.

Samples will be stored by those individuals or facilities designated on the COC Record form (Drawing 5.8). The following methodologies will be used to effect proper transfer documentation:

- Samples will be accompanied by a COC Record at all times.

- Samples will be packed properly for shipment so that bottles will not dislodge and/or break during shipment.

- Samples will be shipped via an overnight delivery service and the air bill number will be recorded to facilitate tracking of the package, if necessary;

- Methodology of shipment, courier name(s), and other pertinent information will be recorded on COC Record;

- When samples are split with an outside source or government agency, the split will be noted;

- An Analytical Request Form (Drawing 5.9), which includes a request for laboratory analysis, will be furnished with each sample shipment; and

- All records pertaining to the shipment of a sample will be retained (freight bills, post office receipts, and bills of lading) and maintained with the project files.

The COC Record will be used by personnel responsible for ensuring the integrity of samples from the time of collection to shipment to the laboratory. The laboratory will not proceed with sample analysis without a correctly prepared COC Record and

Analytical Request Form. The laboratory will be responsible for maintaining COC of the sample(s) from time of receipt to disposal.

The COC Record will be signed by each individual who has maintained custody of the samples. Preparation of the COC Record will be as follows:

- The COC Record will be initiated in the field by the person collecting the samples. Every sample will be assigned a unique identification number as described in Section 5.5.3 that is entered on the COC Record. Samples may be grouped for overnight shipment using a single Record.

- The Record will be completed in the field to indicate project, sampling team, etc.

- If the person collecting the sample does not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished By ________________ Received By ______________" will be completed in the field.

- The person transporting the samples to the laboratory or delivering them for shipment will sign the Record as "Relinquished By ___________."

- If the samples are shipped to the laboratory by commercial carrier, the COC Record will be sealed in a watertight container, placed in the shipping container, and the shipping container sealed prior to being given to the carrier.

- If the samples are directly transported to the laboratory, the COC Record will be maintained in the possession of the person delivering the samples.

- For samples shipped by commercial carrier, the waybill will serve as an extension of the COC Record between the final field custodian and receipt in the laboratory.

6.0 EVALUATION OF ASSESSMENT MONITORING DATA

An evaluation of the assessment monitoring data will be performed in order to establish and communicate the spatial boundaries of contaminant plume(s) identified; and identify and communicate contaminant concentration gradients throughout the contaminated area. Accomplishment of these objectives will aid in (1) identifying contaminant source areas, migration pathways and potential receptors; and (2) establishing a basis for corrective action plans, if necessary.

The initial step in the evaluation process involves data reduction. Analytical results will be reviewed and all ground-water contaminant constituents exhibiting a positive detection will be listed. Concentrations of listed constituents will then be recorded for all sampling points. Additional information to be recorded for each constituent/sampling event combination includes:

- Sampling point identification number (or quality control designation).
- Sampling date.
- Practical quantitation limit.
- Reported concentration.
- Reported approximate concentration, if below practical quantitation limit.

The next step involves a quantitative ranking of constituent concentration/sampling point combinations in order to identify likely source areas and establish concentration gradients within the contaminated area. Based on these results, a representative number of constituents or groups of constituents will be selected with which to define the spatial limits of contamination and develop contaminant isopleth contours.

The third step of the evaluation process will be to develop graphical representations of the horizontal and vertical limits of the contamination as well as the approximate gradients of constituent concentrations within the contaminated area(s). Contaminant isopleth contours for selected constituents or groups of constituents will be drawn on plan maps to exhibit lateral extent of contamination.

7.0 ESTIMATION OF THE RATE OF CONSTITUENT MIGRATION

Groundwater travel time or average linear ground-water flow velocity will serve as the basis for estimating the rate of contaminant migration at the facility. Ground-water flow rates should represent the maximum rate of contaminant migration with variations among contaminants due to geohydrochemical processes including molecular diffusion, mechanical mixing, sorption-desorption, ion-exchange, hydrolysis and biodegradation. However, due to the difficulties in estimating the effects of many of the processes on contaminant migration rates and the desire to produce relatively conservative (higher) estimates, only sorption processes will be incorporated into rate calculations.

Ground-water flow velocities will be calculated using the following modification of Darcy's Law:

$$V = K/n(dh/dl)$$

where: K = *Hydraulic conductivity (ft/day)*
n = *Effective porosity (unitless)*
dh/dl = *Hydraulic gradient (ft/ft)*

Initial estimates of hydraulic conductivity will be determined from results of grain size distribution analyses of soil samples as discussed in Section 5.2.3. Hydraulic gradients will be calculated from water level measurements obtained as described in Section 5.5.1.

Distribution coefficients for metals will be obtained directly from published literature, whereas, distribution coefficients for organic chemicals will be calculated from octanol water partition coefficients and estimates of organic carbon content of the aquifer media. Octanol-water partitioning coefficients for organic constituents will be obtained directly from published literature. Estimates of bulk density and porosity will be determined from results of visual/manual classification of soils and standard penetration resistance tests as described in Section 5.1.2. Average velocities of contaminant constituents will then be calculated in accordance with the following equation (USEPA, 1985):

$$v_c = v/R$$

where: v_c = *Average velocity of contaminant constituent (ft/day)*
v = *Average linear groundwater flow velocity (ft/day)*
R = *Retardation factor (unitless)*

8.0 PROJECT SCHEDULE

A schedule for implementation of the Comprehensive Site Assessment Workplan, along with appropriate milestones, is exhibited in Drawing 8.1.

9.0 REFERENCES

Driscoll, F.G., 1986. Groundwater and Wells, Johnson Division, St. Paul, Minnesota, 1089 p.

Federal Register Vol. 49, No. 209, 40 CFR Part 136, Test Procedures for the Analysis of Pollutants Under the Clean Water Act, October 26, 1984.

Groundwater Section, North Carolina Department of Environment, Health and Natural Resources, Comprehensive Site Assessments at LUST Sites: Basic Tasks and Minimal Elements.

Harned, Douglas A., (Loyd, Jr., Orville B. and Treece, Jr., M.W., Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina, U.S. Geological Survey Water-Resources Investigations Report 89-4096, 1989.

NUS Corporation, Draft Field Investigation/Focused Feasibility Study, Camp Geiger Fuel Spill Site, (Study 90-18), December 1990.

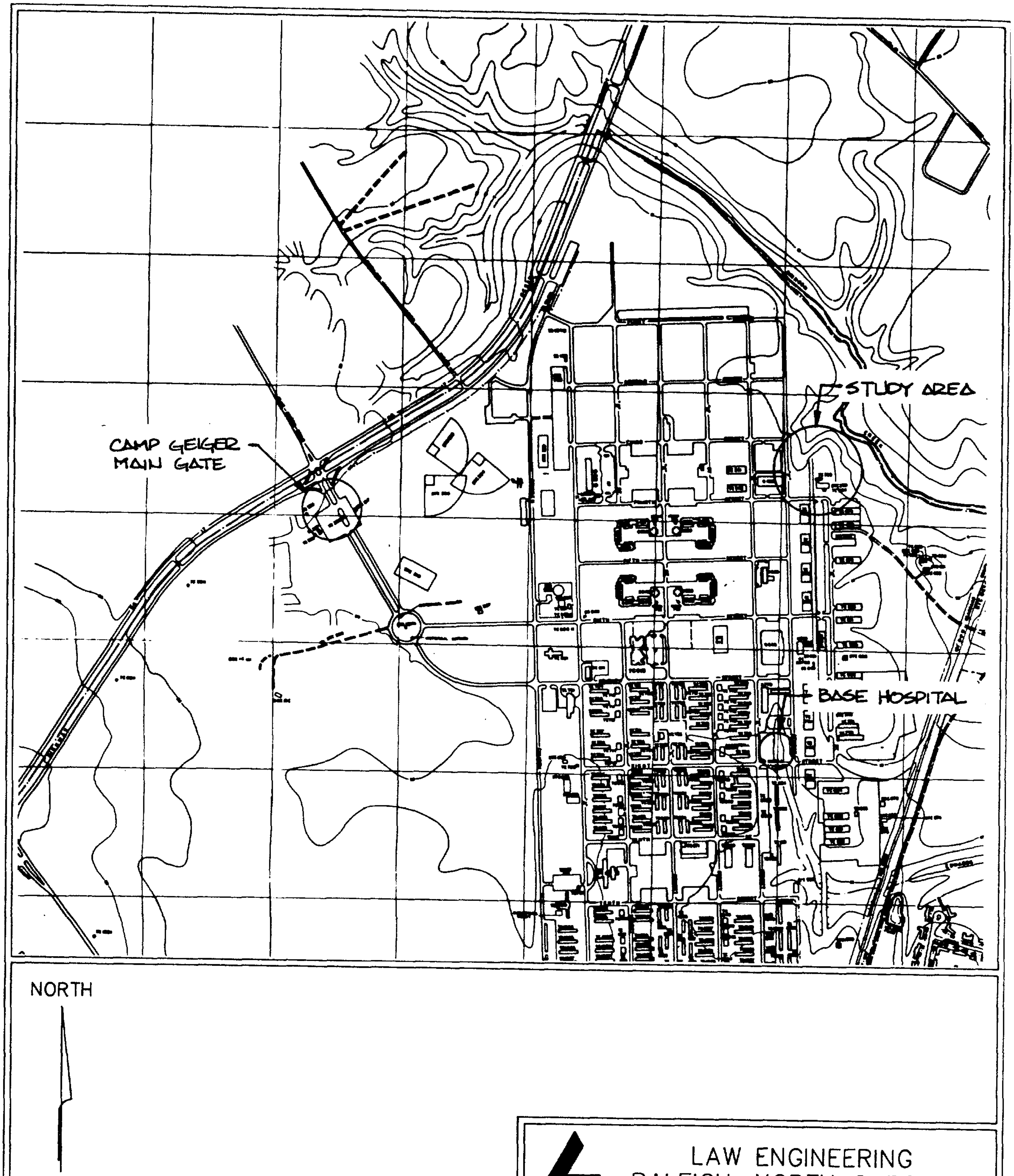
Solid Waste Section, North Carolina Department of Environmental, Health and Natural Resources, North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities, Document No. SW-1001-87, 1987.

United States Environmental Protection Agency (USEPA), 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Parts I & II, Environmental Research Laboratory, Office of Research and Development, Athens, Georgia.

United States Environmental Protection Agency, 1986. Test Methods for Evaluating Solid Wastes (SW-846), 3rd Edition, Vol. II, Office of Solid Waste, Washington, DC.

DRAWINGS

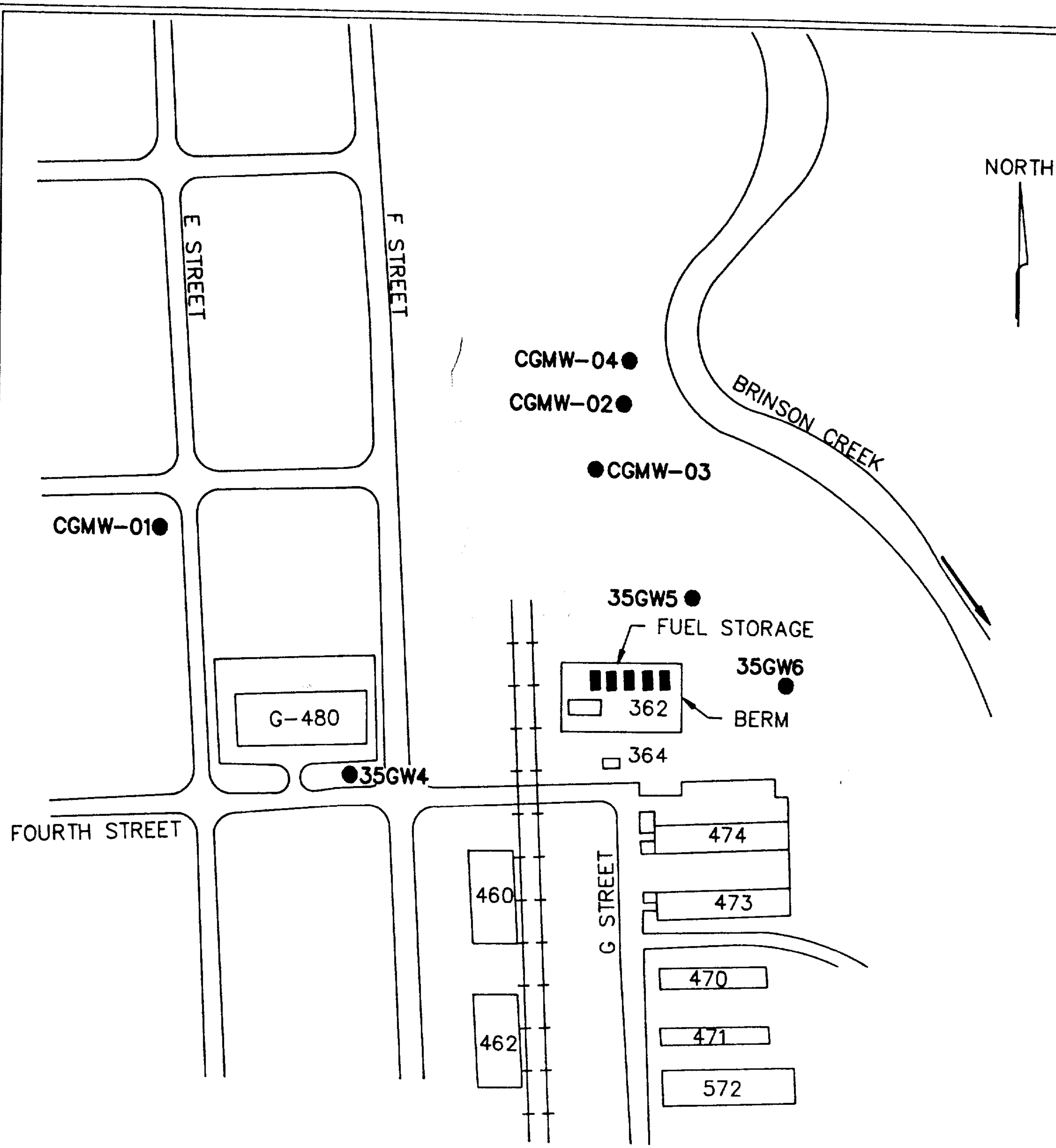
LAW ENGINEERING



LAW ENGINEERING
RALEIGH, NORTH CAROLINA

GENERAL SITE LOCATION
CAMP GEIGER FUEL FARM
NAVY UST/GROUND-WATER ASSESSMENT
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: JULY 1991
DFT CHECK:	SCALE: 1"=1000'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 1.1



LEGEND

● EXISTING MONITORING WELL
460 BUILDING OR STRUCTURE ID NUMBER

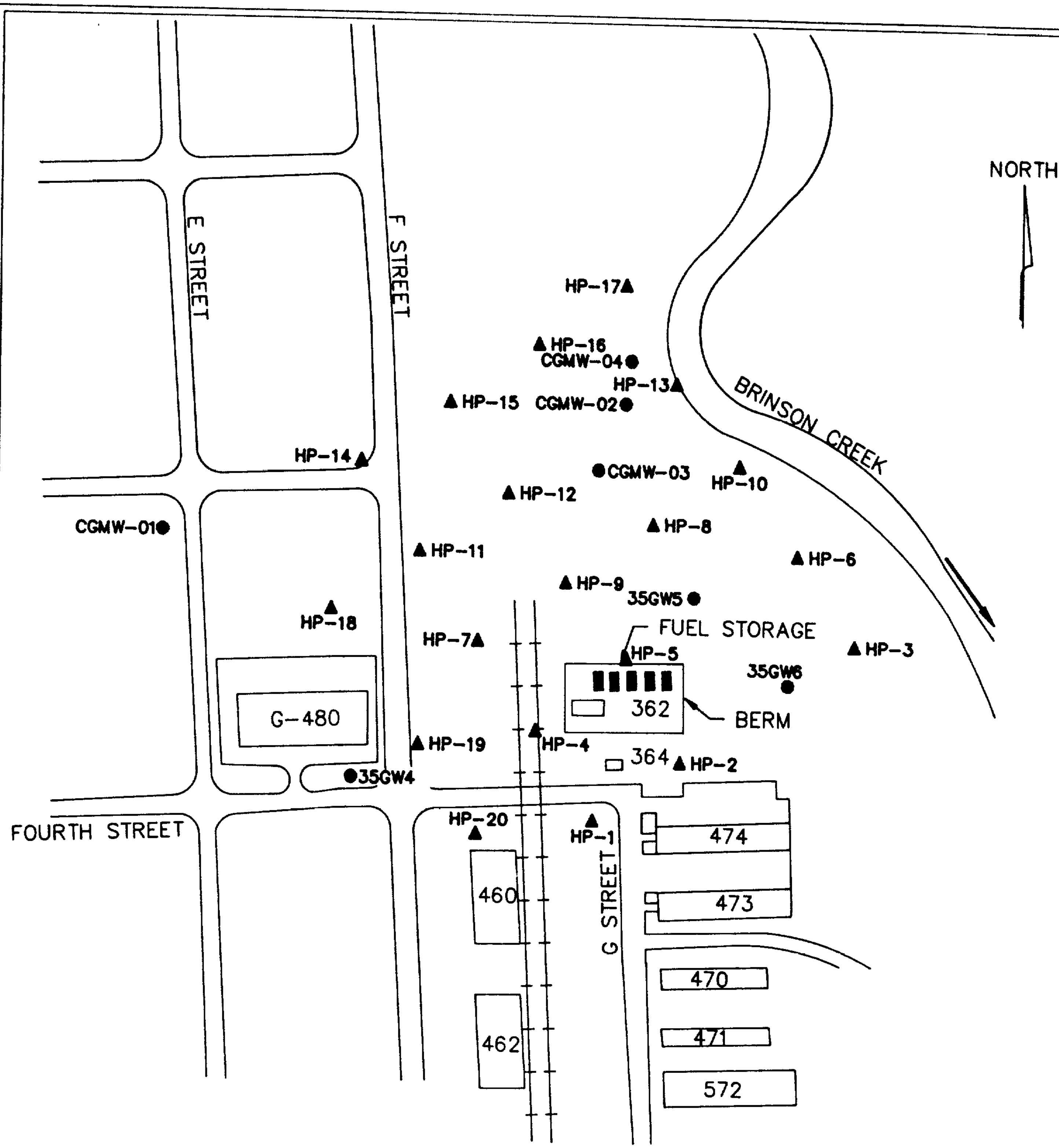
J6014B04

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

EXISTING GROUND-WATER MONITORING NETWORK
CAMP GEIGER FUEL FARM
NAVY UST/GROUND-WATER ASSESSMENT
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: JULY 1991
DFT CHECK:	SCALE: 1"=200'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 3.1

REFERENCE: WATER AND AIR RESEARCH, INC.; 1983; ESE, 1987.



LEGEND

▲ PROPOSED HYDROPUNCH SAMPLE LOCATION
● EXISTING MONITORING WELL
460 BUILDING OR STRUCTURE ID NUMBER

J6014B05

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

HYDROPUNCH SAMPLE LOCATION MAP
CAMP GEIGER FUEL FARM
NAVY UST/GROUND-WATER ASSESSMENT
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: JULY 1991
DFT CHECK:	SCALE: 1"=200'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 5.1

REFERENCE: WATER AND AIR RESEARCH, INC.; 1983; ESE, 1987.

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100

REMARKS:

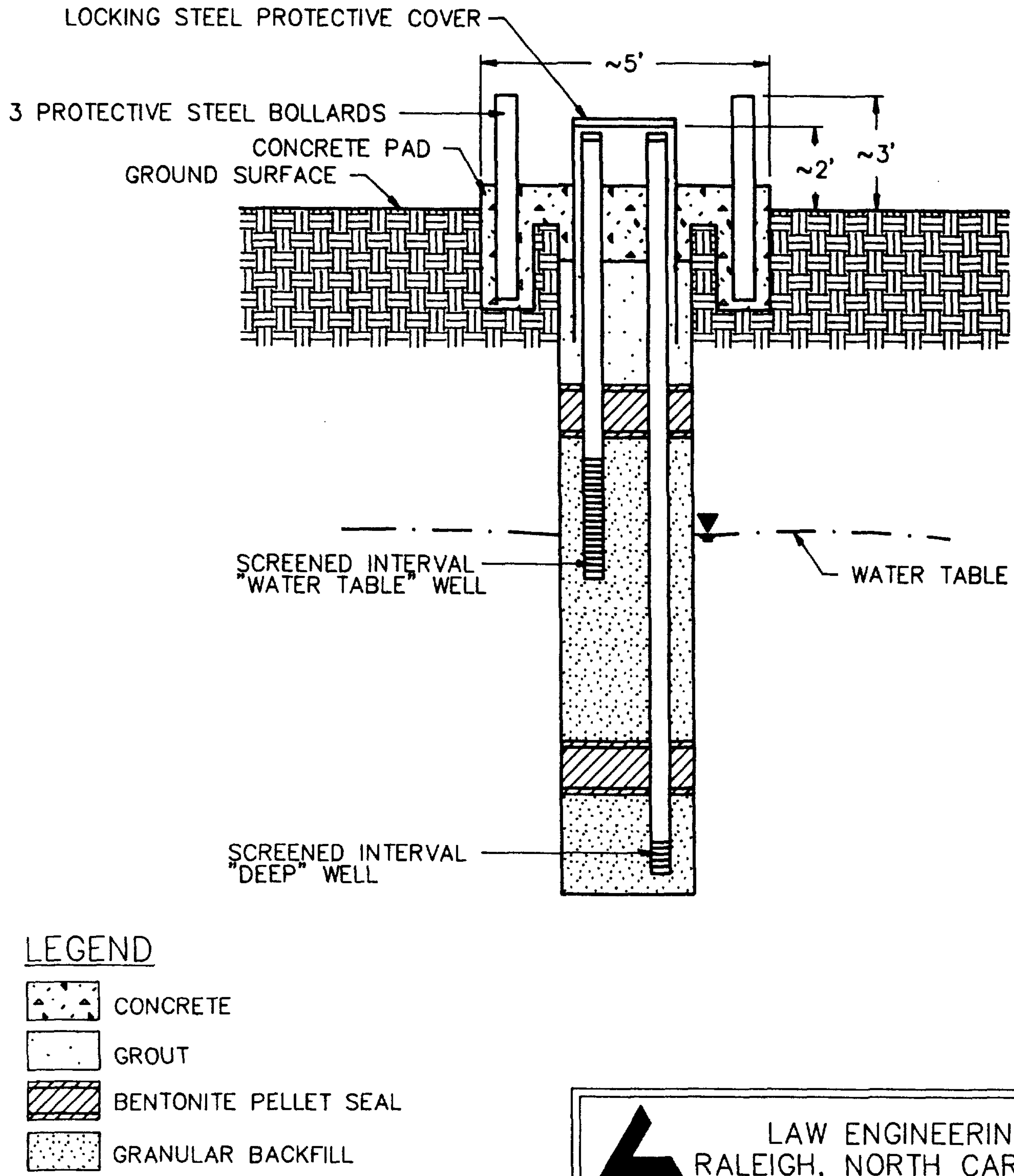
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS USED ABOVE

TEST BORING RECORD

BORING NUMBER
DATE DRILLED
PROJECT NUMBER
PROJECT
PAGE OF

Drawing No. 5.2

LAW ENGINEERING



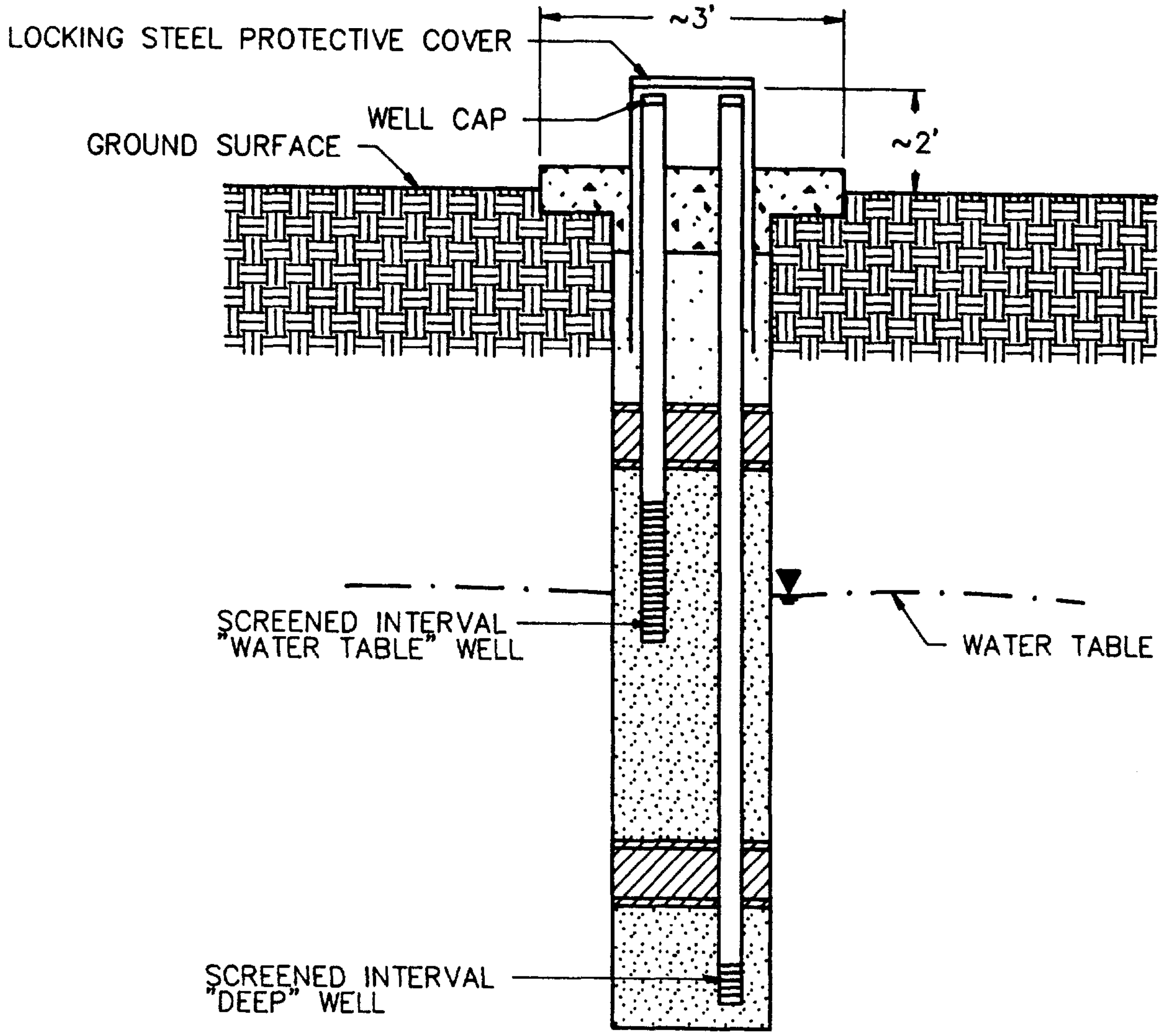
J6014R01

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

PAIRED MONITORING WELL SCHEMATIC
DEVELOPED AREAS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: [signature]	DATE: JULY 1991
DFT CHECK: [signature]	SCALE: NOT TO SCALE
ENG CHECK: W D Dixon	JOB: J47590-6014
APPROVAL: W D Dixon	DWG: 5.3

REFERENCE:



LEGEND

- CONCRETE
- GROUT
- BENTONITE PELLET SEAL
- GRANULAR BACKFILL

J6014R03

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

PAIRED MONITORING WELL SCHEMATIC
UNDEVELOPED AREAS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: JULY 1991
DFT CHECK:	SCALE: NOT TO SCALE
ENG CHECK: W D Dixon	JOB: J47590-6014
APPROVAL: W D Dixon	DWG: **5.4**

REFERENCE:

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT, HEALTH AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL MANAGEMENT - GROUNDWATER SECTION
P.O. BOX 27687 - RALEIGH, NC 27611-7687
PHONE (919)733-3221

FOR OFFICE USE ONLY

Quad. No. ________ Serial No. ________
Lat. ________ Long. ________ Pc ________
Minor Basin ________
Basin Code ________
Header Ent. ________ GW-1 Ent. ________

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR ________

DRILLER REGISTRATION NUMBER ________

STATE WELL CONSTRUCTION PERMIT NUMBER: ________

1. WELL LOCATION: (Show sketch of the location below)

   Nearest Town: ________ County: ________

   ____
   (Road, Community, or Subdivision and Lot No.)

2. OWNER ________

   ADDRESS ________
   (Street or Route No.)

   ____
   City or Town State Zip Code

3. DATE DRILLED ________ USE OF WELL ________
4. TOTAL DEPTH ________ CUTTINGS COLLECTED ☐ Yes ☐ No
5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☐ No
6. STATIC WATER LEVEL: ________ FT. ☐ above ☐ below TOP OF CASING,
   TOP OF CASING IS ________ FT. ABOVE LAND SURFACE.
7. YIELD (gpm): ________ METHOD OF TEST ________
8. WATER ZONES (depth): ________
9. CHLORINATION: Type ________ Amount ________
10. CASING:

Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From ____ To ____ Ft.			
From ____ To ____ Ft.			
From ____ To ____ Ft.			

11. GROUT:

Depth	Material	Method
From ____ To ____ Ft.		
From ____ To ____ Ft.		

12. SCREEN:

Depth	Diameter	Slot Size	Material
From ____ To ____ Ft.	in.	in.	
From ____ To ____ Ft.	in.	in.	
From ____ To ____ Ft.	in.	in.	

13. GRAVEL PACK:

Depth	Size	Material
From ____ To ____ Ft.		
From ____ To ____ Ft.		

DRILLING LOG

Depth From	Depth To	Formation Description

If additional space is needed use back of form.

LOCATION SKETCH

(Show direction and distance from at least two State Roads or other map reference points)

Drawing No. .5.5

14. REMARKS: ________

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

____
SIGNATURE OF CONTRACTOR OR AGENT DATE

Submit original to Division of Environmental Management and copy to well owner.

Law Engineering
3301 Atlantic Avenue
Raleigh, North Carolina 27604

ENVIRONMENTAL DEPARTMENT

MONITORING WELL AND SAMPLING FIELD DATA WORKSHEET

LAW JOB NUMBER ______________ MONITORING WELL NUMBER ______________

SITE NAME ______________

DATE (MO/DAY/YR) ______________ TIME (MILITARY) ______________

FIELD PERSONNEL ______________

UPGRADIENT ______________ DOWNGRADIENT ______________

WEATHER CONDITIONS ______________

AIR TEMPERATURE ______________ °C

TOTAL WELL DEPTH (TWD) ______________ 1/100 FT.

DEPTH TO GROUNDWATER (DGW) ______________ 1/100 FT.

LENGTH OF WATER COLUMN (LWC) = TWD − DGW = ______________ 1/100 FT.

ONE STANDING WELL VOLUME (SWV) = LWC X ______________ GAL

THREE STANDING WELL VOLUMES = 3 X SWV = ______________ GAL = STANDARD EVACUATION VOLUME

METHOD OF WELL EVACUATION ______________

TOTAL VOLUME OF WATER REMOVED ______________ GAL

CASING DIAMETER ______________

CASING MATERIAL PVC ______ S.S ______ TEFLON ______ OTHER ______

MEASURING POINT ELEVATION ______________ DATUM ______________

HEIGHT OF RISER (ABOVE LAND SURFACE) ______________

SCREENED INTERVAL ______________

STEEL GUARD PIPE AROUND CASING YES ______ NO ______ COMMENTS ______

LOCKING CAP YES ______ NO ______ ______

PROTECTIVE POST/ABUTMENT YES ______ NO ______ ______

WELL INTEGRITY SATISFACTORY YES ______ NO ______ ______

WELL YIELD LOW ______ MODERATE ______ HIGH ______ COMMENTS ______

FIELD ANALYSES

VOLUME (GAL.)				
pH (S.U.)				
SP. COND. (µMHOS/CM)				
WATER TEMP. (°C)				
EH (mV)				
TURBIDITY*				

*VISUAL DETERMINATION ONLY

(1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

Drawing No. 5.6

J475R02

Law Engineering
3301 Atlantic Avenue
Raleigh, North Carolina 27604
ENVIRONMENTAL DEPARTMENT

MONITORING WELL CASING AND WATER ELEVATION WORKSHEET

PROJECT NAME ____________________ JOB NUMBER ____________________

LOCATION ____________________ DATE ____________________

SURVEY DATUM ____________________ FIELD PERSONNEL ____________________

MEASURING DEVICE ____

WELL NUMBER	MEASURING POINT CALCULATIONS			DEPTH TO WATER (FT)	ELEV OF WATER (FT)	PRODUCT THICKNESS (ET)	COMMENTS
	ROD HEIGHT (FT)	INSTR. HT. (V=T)	ELEV OF CASING (FT)				ODOR, WELL COND., LOCK PROTECTIVE COVER CONDITION
							Drawing No. 5.7

PAGE _____ OF _____

1762

LAW ENVIRONMENTAL, INC.
NATIONAL LABORATORIES
7215 PINE FOREST ROAD
PENSACOLA, FLORIDA 32526
(904) 944-9772

CHAIN OF CUSTODY RECORD

SAMPLING INFORMATION

NAME OF FACILITY: ______________________

STREET ADDRESS: ______________________

CITY/STATE: ______________________ ZIP: __________

PROJECT NAME	JOB NO.

SAMPLERS (SIGNATURE)

SAMPLING DATE

CONTAINER TYPE

TIME	GRAB	COMP.	SOURCE CODE *	SAMPLE STATION DESCRIPTION	TOTAL NO. OF CONTAINERS	40 ml/G VOA HCl	1 L G, P (HNO_3)	1 L G, P (NaOH)	1 L G, P (H_2SO_4)	1 L G, P	1 L P, (NaOH + Ascorbic Acid)	1 L Teflon	1 L G, P (Zn Acetate + NaOH)	8 oz. G, P	1 L G. Amber	1 L P. Opaque	250 ml/G - Amber							LENL LAB NO.

RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	RECEIVED BY: (SIGNATURE)	DATE/TIME
RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	RECEIVED AT LABORATORY: (SIGNATURE)	DATE/TIME

DISTRIBUTION: ORIGINAL AND YELLOW COPIES ACCOMPANY SAMPLE SHIPMENT TO LABORATORY.
PINK COPY RETAINED BY SAMPLERS. YELLOW COPY RETAINED BY LABORATORY.

REMARKS: ______________________

* SOURCE CODES:
- RECOVERY WELL - RW
- RCRA MONITORING WELL - MW
- SOIL/SEDIMENT - SO
- SLUDGE - SL
- NPDES DISCHARGE - ND
- DRINKING WATER - DW

Drawing 5.8

Law Environmental, Inc.
7215 Pine Forest Road
Pensacola, Florida 32526
904/944-9772

Analytical Request Form

To: ______________________ Attn: ______________________

From: ______________________ ______________________

(Branch/Company Name) (Dept or Name)

COC Number: ______________________

Project Name: ______________________ Project Number: ______________________

Date Shipped: ______________________ Date results requested: ______________________

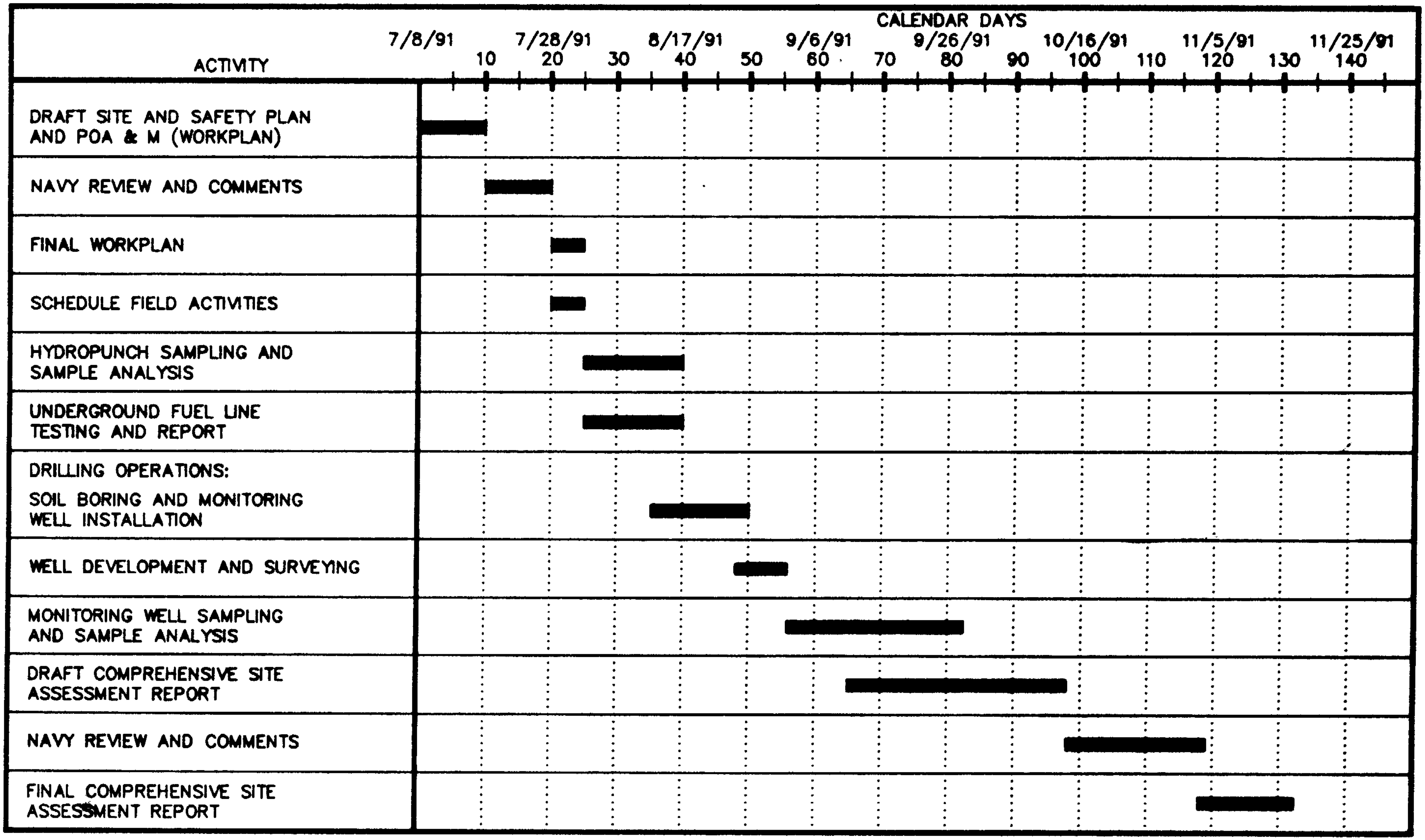
Sample ID	Analysis Requested	Detection Limits Req.	Sample Type	Method

Comments:

Drawing 5.9

DRAWING NO. 8.1 – PROJECT SCHEDULE

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
UNDERGROUND FUEL INVESTIGATIONS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA



J6014B03

APPENDIX A

TRACER RESEARCH CORPORATION'S TRACER TIGHT (tm) Standard Operating Procedures

Tracer Research Corporation

TRACER RESEARCH CORPORATION'S

TRACER TIGHT(tm)

STANDARD OPERATING PROCEDURES

MAY 1991

TABLE OF CONTENTS

Figures

TRACER TIGHT(tm) TANK TESTS

TRACER TIGHT(tm) is TRC's patented tank tightness testing method. TRACER TIGHT(tm) is performed by mixing a tracer, a volatile chemical concentrate, with the product inside of a tank or pipe. If the product leaks out of the system the tracer escapes from the liquid product by evaporation. The tracer vapors are released into the soil and migrate in all directions from the leak through the soil porosity.

Special probes or tubing are placed in the soil near the tanks and pipes to collect the tracer vapors that will appear in the soil in the event of a leak. The vapors are collected from the soil and analyzed for the presence of tracer by means of an extremely sensitive chromatographic measurement.

The tracer is added to the product in very low concentrations typically only a few ppm. Thus, it has no impact on the physical properties of the product. The tracer vapors can be detected in the low parts per trillion level in the soil. For this reason the method is capable of detecting very small leaks in the tanks and pipes.

The tracer chemical, being highly volatile, distributes itself into both the fuel and the vapor space above the fuel inside the tank. Because of its ability to escape through leaks in the vapor space of a partially full tank, there is no requirement to top-off tanks with fuel before testing.

There are several fundamental advantages to the non-volumetric TRACER TIGHT(tm) test over the volumetric testing approach. First, the use of the TRACER TIGHT(tm) method provides leak testing with a much greater degree of convenience and assurance. For example, the tracer method is completely non-disruptive to normal operations involving the tanks. Two to three weeks prior to testing, a tracer is released into the product inside the tank. Only normal fuel usage is required to distribute the tracer throughout the entire system. No addition of fuel to top off the tank is required. No additional personnel are required to coordinate the day to day activities of the leak detection operations.

All leaks are typically identified and located without any tank modifications or digging. As a result, the TRACER TIGHT(tm) method is much more convenient to both the tank users and contract administrators than volumetric tank testing.

The TRACER TIGHT(tm) method will also bring much greater assurance of quality than volumetric testing. The TRC method, like other non-volumetric vapor detection methods, is known to be a quatum leap beyond volumetric methods in terms of sensitivity. For example, when the U.S. Army Corps of Engineers evaluated the TRACER TIGHT(tm) method along with several volumetric methods at March AFB in June 1986, TRC detected and quantified leakage simulated as low as 0.0003 gallons per hour.

Because variables such as tank size, thermal expansion of fuel, air pockets, or other variables that effect volumetric methods, do not impact the tracer testing method, the results are far less ambiguous. Therefore, the greater sensitivity couples with absence of potentially misleading variables makes the tracer method the most accurate and most quality assured method available.

METHOD OF ADDING THE TRACER

The initial step involves inoculating a tracer into each tank. Tracer kits are mailed to designated site personnel. A set of written instructions detail the very simple procedure of adding tracer to the tanks. If multiple tanks are located in the same excavation, different tracers are provided for adjacent tanks. This will identify the tank system that has the leak. Once the tracer has been added the tank system should be used normally. The target concentration for tracer in the tank is typically 10 ppm (1 quart tracer per 50,000 gallons of fuel). However, if the throughput of fuel is great enough to remove the tracer completely in two or three days, a higher concentration will be initiated, up to 100 ppm.

TANK TEST METHOD

The testing of the tank(s) is typically performed approximately 21 days after tracer has been inoculated. This time period is necessary to allow sufficient time for any leakage to occur and time for the tracer vapors to migrate into the backfill to a substantial distance away from the source. Typically, tracer from a leak will disperse into an area at least 25 feet in diameter in this time period. As such, it is easy to detect using probes placed on 10 or 12 foot centers around the tank.

Sample Collection: The procedures for collecting a sample use a 3/4" galvanized steel probe that is driven into the ground by the hydraulic pusher/puller mechanism of the mobile laboratory. If there is concrete or pavement over a sample location, TRC field professionals use a Kango rotohammer to drill a 1-1/2" diameter hole through the surface material. This is useful for going through up to 2" of concrete or 10" of asphalt. A rock drill and air compressor are used on sites with thicker concrete cover.

After 3-5 probe volumes have been drawn through the probe using a vacuum pump, a gas sample is collected with a 10cc glass syringe that is inserted through a section of silicone tubing (leading to the vacuum pump) and through the metal tubing of a special adaptor (Figure 1). Gas samples only

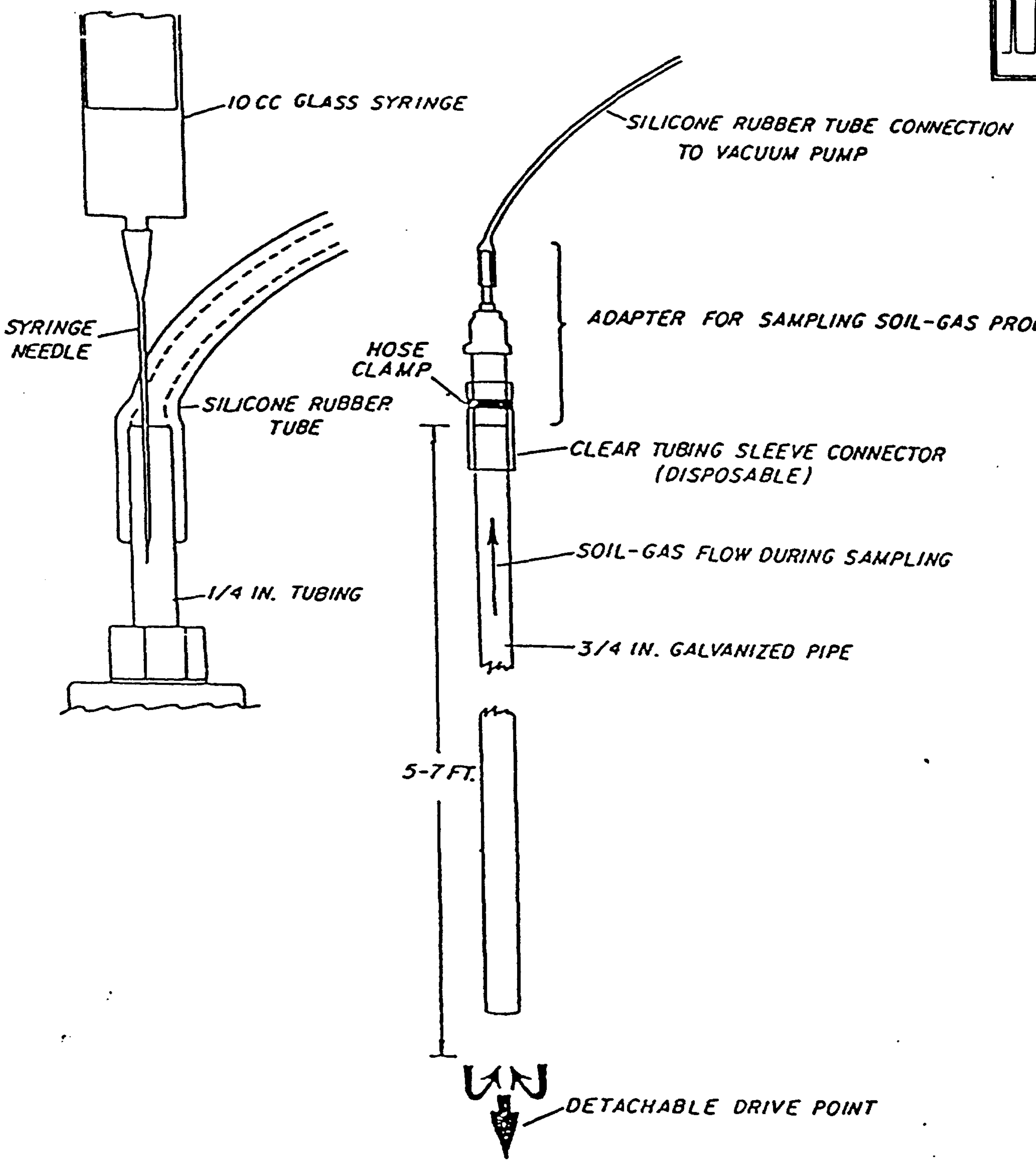


FIGURE 1. SAMPLING APPARATUS

1A. CLOSE-UP OF SYRINGE SOIL GAS SAMPLING THROUGH EVACUATION LINE
1B. DIAGRAM OF SOIL GAS SAMPLING PROBE WITH ADAPTOR FOR SAMPLING AND EVACUATION OF THE PROBE AFTER IT IS DRIVEN INTO THE GROUND

contact decontaminated metal surfaces and are never in contact with potentially sorbing materials (i.e. tubing, hose, pump diaphragm). A vacuum gauge monitors the negative pressure in the evacuation line to assure that there is no impedance to gas flow caused by clayey or water-saturated soils.

The time to conduct the tank test depends on the amount of time required to install the soil gas sample probes. Once a sample is obtained it is analyzed for tracer presence and total volatile petroleum hydrocarbons (tvphc).

Sample Analyses: The sample is immediately injected into the GC for analyses of tracer and TVPHC which is accomplished in less than ten (10) minutes per sample. The analytical procedures identify the halocarbon and hydrocarbon compounds (if any) by chromatographic retention time.

Quantification of compounds is achieved by comparison of the detector response of the sample with the response measured for calibration standards(external standardization). At the beginning of each day, standards are analyzed to calibrate the analytical equipment and determine daily response factors. Chemical standards are prepared in water from commercially available pure standards stored in methanol. Prior the running standards, the water for standards is analyzed for purity. At least three standard injections are analyzed until resultant responses fall within 25% of each other. Response factors are than calculated based on these standard responses. Analyses for halocarbons are run on the electron capture detector(ECD) and those for hydrocarbons are run on the flame ionization detector(FID) as the samples are collected.

Decontamination: All sampling equipment (i.e. probes and syringes, etc) are used only once and then decontaminated. The probes are decontaminated with soap and high pressure hot water spray or steam-cleaned to eliminate the possibility of cross-contamination. Forty to sixty probes are carried on each van to avoid the need to reuse any during the day. The special probe adaptors, used to connect the sample probe to the vacuum pump thus eliminating the possibility of exposing the active sampling stream to any part of the adaptor. Associated tubing connecting the adaptor to the vacuum pump is replaced periodically as needed during the job to insure cleanliness and good fit. At the end of each day, the adaptor is cleaned with soap and water and subsequently baked in the GC oven. Silicon tubing used to connect the adaptor to the vacuum pump is replaced as needed to insure proper sealing around the syringe needle. This tubing does not directly contact the samples.

The analytical equipment is decontaminated every night.

Glass syringes are used for only one sample per day and are washed and baked each night. GC injection port septa through which soil gas samples are injected into the chromatograph are replaced on a daily basis to prevent possible gas leaks from the chromatographic column. The decontamination is verified by using the syringes to inject nitrogen carrier gas into the gas chromatograph each day.

CRITERIA FOR PASSING OR FAILING THE TEST

Since the tracer is not previously present in the environment around the tank, detection of tracer with the very sensitive laboratory grade gas chromatograph will indicate leakage. To verify the existence of a leak, a comparison is made to the total hydrocarbon content of a sample from the same probe. An abnormally high hydrocarbon content tends to confirm the presence of a leak. It is possible that tracer can be discharged to the environment from surface spills or sloppiness in adding the tracer to the tank contents. However, in the case of a surface spill, the extreme volatility of the tracer results in it evaporating before it can penetrate the ground. What little does contact the ground will not penetrate very deeply and this becomes obvious when the samples are analyzed. Additional verification is obtained during the location process which is described in the following section that provides details on the pass/fail criteria.

ADDITIONAL LEAK VERIFICATION & LOCATION TECHNIQUES

After tracer is detected, additional probing on five foot centers is performed to locate the source of the leakage. The leak is considered to be closest to the highest tracer concentration observed. Once a leak is detected, it is classified to provide information about the severity of the problem.

The classification of leakage is based on the concentration of tracer detected. Measurements of hydrocarbons outside of the tank is provided for the benefit of the tank owner. The following criteria are used for the classification of leaks when tracer is detected.

LEAK STATUS

PASS - Leak rate less than 0.05 gallons per hour.

Criteria:
- if tracer is less than 0.1 ug/l at 5-6 feet below grade; or
- if tracer is less than 1.0 ug/l & if concentration decreases with an increase in depth.

FAIL - Leak rate equal to or greater than 0.05 gallons per hour.

Criteria:
- if tracer is greater than or equal to 1.0 ug/l at any depth; or

if tracer is greater than or equal to 0.1 ug/l &
if the concentration sustains * or increases with an increase in depth.

* Sustaining concentrations are those concentrations which are within 50% of the concentration detected at the shallow depth.

The above system for interpreting the magnitude of leakage based on the distribution of tracer and hydrocarbon vapors in the soil was developed out of TRC's experience in detecting leakage that has been either quantified by leak rate measurements or confirmed by excavations. Accurate leak rate measurement can be performed using TRC's high volume air evacuation method, but this procedure is relatively expensive in view of the purpose that the leak rate information serves. The magnitude of the leak can be adequately described for the purpose of deciding on corrective action using the information obtained from the passive test.

The TRC field professionals make a scale drawing of the site showing the tank location, apparent or probable piping locations, all of the soil gas probe locations and other pertinent features such as tank fill and vent locations, fuel dispensers, concrete aprons and portions of adjacent buildings. The distribution of contamination is also shown on the site map if leakage is detected.

All of the data collected by TRC is first generated by a gas chromatograph in the form of instrument printouts called chromatograms. The data from the chromatogram is entered into a computer where it is reduced and manipulated. In addition to the computer generated data sheets, a hand-drawn map view of the tanks and all sampling locations is generated. The samples are noted on the map and numbered. The sample number is written on the chromatogram and entered into the computer where it is referenced to the chromatogram by the injection time.

CERTIFICATION

The TRACER TIGHT(tm) tank and pipeline testing method was evaluated using the EPA test protocol "Standard Test Procedures for Evaluating Leak Detection Methods: Non-volumetric Tank Tightness Methods." The results indicate that the method is capable of detecting leaks of 0.05 gallons per hour with a Probability of Detection of 0.97 and Probability of False Alarm of 0.029. With these results, the method exceeds the federal requirements that leak detection systems be capable of detecting leaks of 0.1 gallons per hour with a Probability of 0.95 or greater.

Tracer Research Corporation also participated in an evaluation of tank testing methods in June of 1986. The test was conducted at March AFB by Midwest Research Institute (MRI) for the Army Corps of Engineers. In this test, each of the participating companies were given a 50,000 gallon JP4 tank to test. In order to obtain immediate results, TRC used a high rate of air evacuation from the probes. MRI evaluated each of the company's methods by simulating leakage. Each company was required to detect the simulated leakage and make an estimate of the leak rate. TRC was able to detect leakage of 0.00032 gallons per hour(gph). TRC estimated the leak rate at 0.0004 gph which was within 25% of the actual leak rate.

The report provided by MRI to the Army Corps of Engineers details the method used and the test results. The MRI report clearly points out that the tracer method is not impacted by tank size, thermal effects or product vapors outside the tank and recommends it as the best available method for large tanks.

APPENDIX B

HEALTH AND SAFETY PLAN

LAW ENGINEERING

HEALTH AND SAFETY PLAN
CAMP GEIGER FUEL FARM INVESTIGATION

PROJECT NAME:	***Camp Geiger Fuel Farm Assessment***
LOCATION OF SITE:	Camp Geiger MCAS
LAW JOB NO.:	J47590-6014
CLIENT:	United States Navy Department-Atlantic Division

REVIEW AND APPROVAL

Principal Geologist	J. Allen Kibler, Jr., P.G.	
Project Manager	W. Douglass Dixon, P.E.	W Douglass Dixon
Site Manager	Rick Kolb	Randy Pulley for

DATE OF PLAN PREPARATION

July 24, 1991

DATES OF PLANNED FIELD ACTIVITIES

August 5 - September 30, 1991

SAFETY MEETING CONDUCTED: (LOCATION):________________ (DATE): _____

EMERGENCY PHONE NUMBERS

Base Naval Hospital: Building G770
Hospital route is shown on attached Drawing 1.1.

Base Naval Hospital:	451-0595	
Base Fire Department:	911	
Military Police:	451-2555	
Senior Project Professional:	J. Allen Kibler	(919) 876-0416
Health and Safety Officer:	Stanley J. Harward	(919) 876-0416
Military Contact:	Stephany Del Re'-Johnson	(919) 451-5093

DESCRIPTION OF POTENTIAL HAZARDS

- Exposure to petroleum fuels through inhalation, skin absorption or ingestion
- Fire or Explosion
- Vehicular Traffic

LAW ENGINEERING

PERSONNEL ACCESS

Personnel who attended LAW's site safety meeting and are authorized to enter this site:

1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________
5) ______________________________
6) ______________________________
7) ______________________________
8) ______________________________
9) ______________________________
10) ______________________________

By signing this form, the listed individual acknowledges that he has read, and understands, and will comply with the requirements of this Health and Safety Plan.

PLANNED FIELD ACTIVITIES

- Perform 20 Hydropunch samples to an approximate depth of 10 feet.
- Perform 6 soil test borings to an approximate depth of 10 feet.
- Install 20 "paired" ground-water monitoring wells to an approximate depth of 30 feet.
- Decontamination of drilling equipment.
- Develop and sample monitoring wells.
- Dispose of drill cuttings and purged water.

MONITORING PROCEDURES

Ambient air monitoring for the presence of volatile organic compounds with a photoionization detector (PID) will be periodically performed in the drilling area. Testing will be conducted for approximately three minutes at a minimum of one test per hour or at other times when site conditions (e.g. evidence of free product, increase in detectable odors, site workers sensitivity) exhibit the need for additional testing. The Site Manager will record the time, location and result of each test. In the event that PID readings exceed a level of 50 ppm for more than one-half of any three-minute testing interval, the work site will be evacuated pending additional testing or proper ventilation. The action level of 50 ppm represents the permissible exposure limit (PEL) for naphtha and coal tars as established by the Occupational Safety and Health Administration (OSHA). If further testing reveals that ambient air contains volatile organic compounds in excess of 50 ppm, respirators designed for removal of toxic organics will be required for all site workers. Should concentrations exceed 2500 ppm, all site work will cease and the site will be evacuated pending guidance from the Corporate Health and Safety Officer.

Continuous ambient air monitoring for the presence of explosive gases with an explosimeter will be performed in the drilling area at suspect locations. All personnel access/work in the drilling area must STOP if air readings exceed 20% of Lower-Explosive Limit (LEL) until readings consistently exhibit concentrations of gases at less than 20% LEL.

DECONTAMINATION (Petroleum products)

Skin	-	wash with soap and water
Eyes	-	flush with copious amounts of water
Clothing	-	wash with detergent and rise thoroughly
Equipment	-	steam clean or detergent wash

MEDICAL SURVEILLANCE

All Law Engineering field personnel participate in the corporate annual environmental medical surveillance program.

Avoid frequent or prolonged skin contact. Monitor skin and eyes for dermatitis, allergic reaction, and eye irritation. If these or other symptoms develop, seek qualified medical attention.

Symptoms of Acute Exposure to Petroleum Hydrocarbons: High vapor levels can cause irritation of the respiratory tract, headaches, nausea and mental confusion. Los of consciousness occurs with very high concentrations. Liquid contact with skin may cause defatting, drying and irritation. Both vapor and liquid phases are irritating to the eyes.

EMERGENCY PROCEDURES (Petroleum products)

Skin	-	wash with soap and water, rinse well
Inhalation	-	move to fresh air at least 50 feet upwind from vapor source. Seek qualified medical attention.
Ingestion	-	do not induce vomiting. If conscious, give water or milk to drink. Seek qualified medical attention.
Eyes	-	flush for a minimum of ten minutes with clean water while holding eyes open. Seek qualified medical attention.

HEAT STRESS

Symptoms of heat stress include pale, cool or moist skin, excessive sweating, dizziness, nausea, and muscle spasms. Symptoms of heat stroke include red, hot and unusually dry skin, reduced perspiration, nausea, dizziness or confusion, rapid pulse rate and coma.

To prevent heat stress, adjust work schedule, provide shaded rest areas, and maintain body fluids.

CLOTHING AND PROTECTIVE GEAR

REQUIRED at work site during drilling activities: Nitrile rubber gloves, steel-toed boots, protective eyewear, hard hats.

** The Project Manager or the Senior Professional should be contacted prior to changes in personal protective equipment usage.

To be READILY AVAILABLE on site:

- Full face respirator with volatile organic cartridges.
- Nitrile rubber boots
- Tyvek suits
- Cotton glove liners, if needed

IN THE EVENT OF PERSONNEL INJURY

Provide basic first aid procedures as required and note time and circumstances of injuries. Call for an ambulance or transport to nearest medical facility (Drawing 1.1) as appropriate. Notify Project Manager and Military Contact.

Only emergency medical care is available in Government facilities to Contractor employees who suffer on-the-job injury or disease. Care will be rendered under the conditions and at the rates in effect at the time of treatment. The contractor shall reimburse the Naval Regional Medical Center Collection Agent promptly upon receipt of statement.

Non-emergency medical services may be obtained at the nearest civilian hospital which is: Onslow Memorial Hospital, 317 Western Boulevard, Jacksonville, North Carolina (919-577-2345).

IN THE EVENT OF POTENTIAL OR ACTUAL FIRE OR EXPLOSION

Evacuate the area immediately. Assemble in the predesignated area and conduct a head count of all personnel. Notify base fire department. DO NOT attempt to fight the fire. Notify Project Manager, Military Contact and the Base Fire Department.

ACCIDENT REPORTING

Personnel injuries and vehicle accidents should be reported to the Branch Safety Officer within 24 hours of incident.

WORK PRECAUTIONS

1) No smoking, eating, drinking or chewing of gum or tobacco products while on the site. Avoid hand to mouth contact. A designated smoking and break area may be established off site. Any such facility must be a minimum of 100 feet from any vapor source and shall be tested for flammable gases and vapors at the start of work and prior to scheduled break periods each day.

2) Hard hats are required to be worn at all times at drilling locations. Face shields or goggles will be worn whenever the potential for chemical splash or flying debris is present. Use of Nitrile gloves and safety glasses are required.

3) Barricade work areas if located in a high vehicular traffic area.

4) Decontamination of equipment, clothing and personnel shall be in accordance with the previous section entitled "Decontamination".

5) Removal and transfer of flammable liquids from a container to receiving vessel requires proper grounding of the container to the receiving vessel in order to prevent build-up and discharge of static electricity.

6) Personnel must wash all exposed skin areas with soap and water before departing the site or going on break.

7) Prior to the start of work, LAW personnel shall be briefed on the contents of this plan by the Project Manager.

SITE MANAGER SUMMARY

During the work covered by this Safety Plan, there were:

___ No observed violations of the Safety Plan provisions.

___ The following violations of the Safety Plan provisions (give details in space below and indicate corrective action taken for each violation noted.)

____

____

____

____

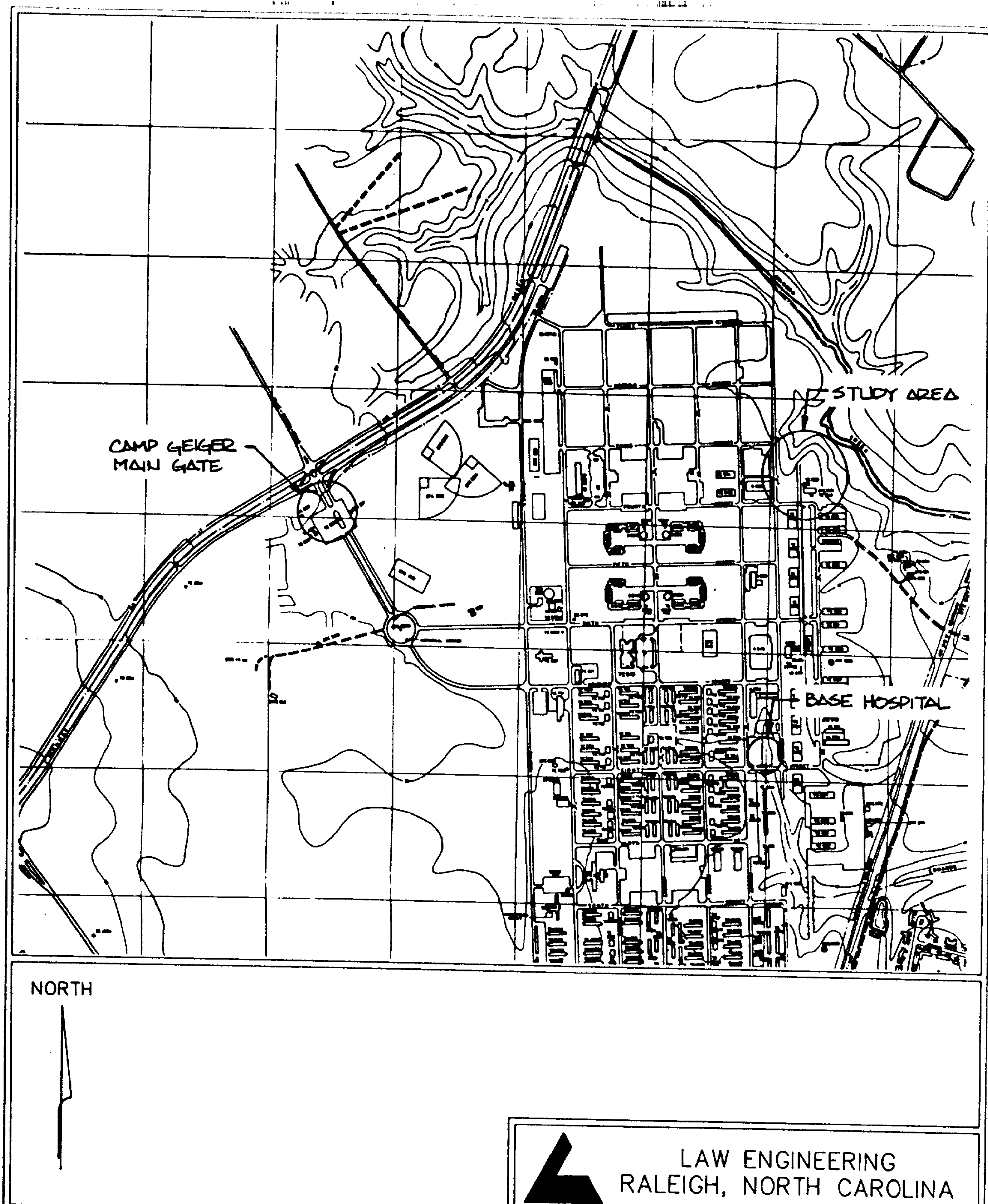
____

____

____

Signature __________________________ DATE ____________

SITE MANAGER



LAW ENGINEERING
RALEIGH, NORTH CAROLINA

GENERAL SITE LOCATION
CAMP GEIGER FUEL FARM
NAVY UST/GROUND-WATER ASSESSMENT
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: JULY 1991
DFT CHECK:	SCALE: 1"=1000'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 1.1