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LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

LEAKING UNDERGROUND STORAGE TANK SITE ASSESSMENT REPORT

VOLUME I

Building TC-341
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

Prepared For:

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

Prepared By:

Law Engineering, Inc.
3301 Atlantic Avenue
Raleigh, North Carolina 27604

April 13, 1994

Law Engineering Job No. 475-09183-01

DRAFT

April 13, 1994

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

Attention: Mr. Mark Barnes
Environmental Engineer, Code 18215

Subject: **LEAKING UNDERGROUND STORAGE TANK**
SITE ASSESSMENT REPORT
HEATING PLANT BUILDING TC-341
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

Dear Mr. Barnes:

In accordance with Naval Facilities Engineering Command Order for Supplies and Services Contract No. N62470-93-D-4020, delivery order number 0001 dated October 29, 1993, Law Engineering, Inc. is pleased to present this report of our environmental services recently performed at the above referenced project site. The scope of our services, as described in the attached Leaking Underground Storage Tank (LUST) Site Assessment Report, included advancement of soil test borings and collection of soil samples for chemical testing; installation of ground-water monitoring wells; collection of ground-water samples from the wells, and investigation of the geology and hydrogeology in the vicinity of the Heating Plant Building TC-341 site, also known as the former Mess Hall Heating Plant, Camp Geiger, Camp Lejeune, North Carolina. The objective of our services was to provide an assessment of the extent/severity of and possible exposure of soils and ground-water to subsurface petroleum contamination caused by leaks from the underground storage tank system at Building TC-341.

This report is intended for the exclusive use of Naval Facilities Engineering Command, Atlantic Division. The contents should not be relied upon by any other parties without the express written consent of Law Engineering, Inc. The findings are relevant to the dates of our site work and should not be relied upon to represent site conditions on other dates.

DRAFT

We appreciate the opportunity to provide environmental services on this project. If any questions arise, please contact us at (919) 876-0416.

Sincerely,

LAW ENGINEERING, INC.

Wayne V. Wilkinson
Senior Environmental Geologist

Brian J. Bellis, P.G.
Principal Hydrogeologist

WVW/BJB/klc

cc: Mr. Tom Morris, Marine Corp Base Camp Lejeune
Ms. Kathy Molino, LANTNAVFACENGOM (cover letter only)

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EXECUTIVE SUMMARY

In accordance with the Naval Facilities Engineering Command Order for Supplies and Services Contract No. N62470-93-D-4020 dated August 29, 1993, Law Engineering preformed a Leaking Underground Storage Tank Comprehensive Site Assessment (CSA) in the vicinity of Heating Plant Building TC-341 at Camp Geiger within the Marine Corps Base (MCB) in Camp Lejeune, North Carolina. The investigation involved the assessment of soil and ground-water quality conditions in the vicinity of Building TC-341, near the former location of a number 6 heating oil underground storage tank (UST) of unknown size and the associated 6-inch diameter fuel supply line which originated at the Camp Geiger fuel farm located east of the site.

The assessment involved the installation of twelve Type II and two Type III monitoring wells and analysis of soil and ground-water samples. Soil samples were tested for total petroleum hydrocarbons (TPH) according to EPA preparation/testing Methods 5030/8015 (volatile fraction), 3550/8015 (semi-volatile fraction) and 9071 (oil and grease), as well as TCLP metals, flash point and pH. Ground-water samples were analyzed for purgeable aromatic hydrocarbons according to EPA Method 602, and polynuclear aromatic hydrocarbons according to EPA Method 610, and also for the eight RCRA metals.

Based upon the results of our investigation, petroleum related contamination is present within soils and ground water within the area of investigation. The majority of soil contamination appears to be located within the immediate vicinity of the underground storage tank (UST) system at the site. Ground-water contamination was detected mainly in the upper portion of the surficial aquifer. Free product is also present in the immediate vicinity of the UST system.

The extent of benzene, ethylbenzene, toluene, total xylenes, methyl-tertiary-butyl ether and polynuclear aromatic hydrocarbons within the shallow ground water has been adequately defined by the sampling network used in this study. Elevated concentrations of PAH compounds at the furthest downgradient well location suggest that other petroleum sources located east of TC-341 have contributed petroleum compounds to the shallow ground water in the area.

Results of this assessment suggest that the majority of soil and ground-water contamination originating from the tank system at Building TC-341 has been adequately defined for the purposes of preparing a Corrective Action Plan.

Based on our assessment of the subject site, soil and ground water both indicated the presence of compounds characteristic of fuel oil that leaked from the UST system at TC-341 and possibly gasoline or Jet fuel from the petroleum source located east of TC-341. The presence of free product in ground-water coupled with elevated concentrations of petroleum constituents requires additional measures to satisfy groundwater requirements set forth by the state.

Our recommendations are as follows:

- Initiate free product recovery activities in the vicinity of the TC-341 UST system.
- Provide a copy of this comprehensive site assessment to the State for their review and files.
- Perform additional investigation to determine the limits of soil and ground-water contamination to the east of Building TC-341.
- Begin preparation of a Corrective Action Plan.

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1.0 INTRODUCTION

1.1 Purpose of Investigation

The Commander of the Atlantic Division Naval Facilities Engineering Command in Norfolk, Virginia, contracted with Law Companies Group, Inc. to perform a Leaking Underground Storage Tank Comprehensive Site Assessment (CSA) at Building TC-341, located on Camp Geiger at the Marine Corps Base at Camp Lejeune, North Carolina (Drawing 1.1). The purpose of the investigation was to identify the presence, magnitude and extent of possible free product accumulation and ground-water contamination, and assess potential exposure to subsurface contaminants resulting from the release of Number 6 heating oil from an underground storage tank (UST) system at the site. As stated in the Leaking Underground Storage Tank Workplan contained in Appendix A, the objective of the investigation was 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. This data should also be sufficient to meet the requirements of Sections .0704 and .0706 of Title 15A, Chapter 2, Subchapter 2N, North Carolina Criteria and Standards Applicable To Underground Storage Tanks and Comprehensive Site Assessments. This report is designed to include information requested by the North Carolina Department of Environment, Health and Natural Resources in accordance with the document entitled "Groundwater Section Guidelines For The Investigation and Remediation of Soils and Groundwater" dated March 1993 (Revised June 1993).

1.2 Scope of Work

Authorization to proceed with the investigation was granted by the Commander of the Atlantic Division Naval Facilities Engineering Command, Norfolk, Virginia, via Contract No. N62470-93-D-4020, Delivery Order No. 0001, dated October 29, 1993. As specified in the contract requirements and outlined in the delivery order, Law Engineering prepared a work plan and health and safety plan to outline a site specific scope of work for field assessment activities.

The investigation involved the advancement of fourteen soil borings from which soil samples were obtained and into which twelve Type II and two Type III monitoring wells were installed. The delivery order also included provisions to sample three of the previously installed Type II monitoring wells.

Soil and ground-water samples were collected from the soil borings and monitoring wells for both on-site and off-site laboratory analysis. The collected data were used to delineate the horizontal and vertical extent of soil and ground-water contamination and to identify potential receptors that could be affected by the release so that a Corrective Action Plan (CAP) for the site can be developed. The specific methods employed during performance of the project activities and the results, conclusions and recommendations of the CSA are described within the appropriate sections of this report.

1.3 Area of Investigation

The site is located east of D Street between Third Street and Fourth Streets at Camp Geiger, Camp Lejeune Marine Corps Base (MCB). The subject UST of this study is located approximately 90 feet west of Building TC-341 and 20 feet east of D Street. The exact location of the UST is not clearly marked or identified on base drawings but can reportedly be identified as a slight cresting of the ground surface. The topography in the vicinity of the site is relatively flat and is at an elevation of approximately 15 feet above mean sea level (msl). Most of the area is not serviced by storm sewers. Runoff generally travels by sheet flow before entering drainage ditches which discharge into Brinson Creek which is located approximately 1000 feet northeast of the site.

2.0 SITE HISTORY AND SOURCE CHARACTERIZATION

2.1 Site History and Operations

Information concerning the history of the project site was provided by Ms. Deborah Pickett with the Installation/Restoration Division of the Environmental Department (EMD/IRD) at Camp Lejeune.

The UST at the subject site was used to supply number 6 heating oil to a former mess hall heating plant which has since been demolished. The UST was reportedly installed around 1941. An underground fuel distribution supply line formerly connected the UST to the Camp Geiger Fuel Farm, located east of the TC-341 site.

2.2 Contaminant Source Inventory

Free product was observed in MW-1 and MW-2 (Drawing 2.1), which are located in close proximity to the UST and the fuel supply line. However, according to EMD/IRD it could not be determined whether the leak occurred from the UST or the associated fuel supply line. Several building structures were once located east of the site which have since been demolished and include an ice house and a gasoline filling station. The Camp Geiger Fuel Farm also is located east of the site. Suspected or known areas of soil and ground-water contamination have been documented for these sites, all of which are located downgradient of the study area with respect to shallow ground-water flow direction and are not expected to affect the subject property.

2.3 Release Incident History

A suspected release from the UST was first documented by Law Engineering, Inc. in September of 1991 during the investigation of the adjacent Camp Geiger Fuel Farm. The study identified the number 6 heating oil UST and associated piping as a potential source of contamination. One soil boring was advanced adjacent to the UST to provide a preliminary determination as to whether or not the tank had leaked. The analysis of two soil samples collected from the boring at 3.0 to 4.5 feet and 8.5 to 10.0 feet below land surface (BLS) (at ground water) detected total petroleum hydrocarbons (TPH) at 8,400 and 5,100 parts per million (ppm), respectively, by EPA preparation/testing Methods 3550/8015 and 5030/8015 (Law Engineering, 1991).

2.4 Previous Investigation

Based upon the findings presented by Law Engineering, Inc. a three well site check was performed at the subject site by ATEC Associates, Inc. in June of 1992. Results of this work are presented in ATEC's report dated September 24, 1993. Each of the three Type II monitoring wells were installed to a depth of 20 feet BLS with 10 feet of 0.010-inch slotted polyvinyl chloride (PVC) screen and 10 feet to PVC riser. Ground water was measured between 9 and 10 feet BLS.

Headspace analysis of soil collected from the three monitor-well soil borings yielded readings ranging from 0 to 119 ppm. Analysis of three soil samples collected from the approximate depth of ground water from each of the three monitoring well borings indicated concentrations of TPH (EPA Method 8015) in each sample ranging from 110 to 2,000 ppm. Analysis of the soil samples for benzene, toluene, ethylbenzene, and xylenes (BTEX) detected total BTEX concentrations in soil samples from monitor-well soil boirngs MW-1 and MW-2 from 155 parts per billion (ppb) to 5,530 ppb, respectively (ATEC, 1992).

Ground-water samples were collected from each of the three monitoring wells and were also analyzed for BTEX. Analytical results indicated total BTEX concentrations of 34 ppb in MW-2. BTEX was not detected in ground-water samples collected from MW-1 and MW-3 (ATEC, 1992).

Ground-water was determined to flow to the east (ATEC, 1992). The rate of ground-water flow in the surficial aquifer was calculated by assuming a porosity of 30 percent, a measured water table gradient of 0.005 ft/ft, and an assumed hydraulic conductivity of 0.28 ft/day for a fine sand aquifer. Based upon this information, a ground-water flow velocity of 0.005 ft per day was calculated (ATEC, 1992).

2.5 History of Corrective Action

The extent of corrective action has been the in-place abandonment of the UST and the associated fuel supply pipeline.

3.0 MIGRATION PATHWAYS AND POTENTIAL RECEPTORS

3.1 Water-Well Inventory

According to a map of the base water supply system provided by EMD/IRD at Camp LeJeune, the closest water supply well (T-15) appears to be located approximately 1000 feet to the northeast of the site. Other water supply wells located within a one-half mile radius of the site include wells TC-104, TC-100, TC-202, TC-325, TC-502, NC-52, TC-600 and TC-700. The approximate locations of these wells with respect to Building TC-341 are shown on Drawing 3.1. All of these wells are located to the west of the site. These wells do not appear to be located hydraulically downgradient of the site. According to Mr. Tom Morris of EMD, all water derived from water supply wells in the Camp Geiger area is treated before use. Drinking water for all Camp Geiger residents is provided by the Camp Geiger main water-treatment plant located near the intersection of 6th Street and Church Street.

3.2 Utility Survey

Subsurface utility trenches can often provide preferential pathways for migration of contaminants. Therefore, an attempt was made to identify and locate subsurface utilities in the vicinity of the site. Information on the location of utilities was provided by MCB Camp LeJeune Facilities Engineering in the form of plans and drawings. Additional information was obtained from interviews with personnel located at the subject site. Based on the information provided, utilities located within the project area include water and wastewater lines, and communication and electrical lines. The approximate locations of underground utility lines located proximal to the site are shown in Drawing 3.2 Typically, underground utilities are buried from 2 to 6 feet BLS. The presence of fill stone, sand or loosely consolidated soils around the below grade utilities could act as potential contaminant migration pathways.

3.3 Potential Receptor Survey

Biological Receptors

Fuel contamination, in any one of four physical states or "phases"[1] (residual, vapor, liquid, dissolved), may be transmitted to receptors via ingestion, inhalation, or absorption. As petroleum fuel seeps through the subsurface, it will undergo a transformation process that results in adsorption of hydrocarbons onto soil particles (residual phase) and release of volatile hydrocarbons into pore spaces (vapor phase). If any product remains after adsorption and volatilization takes place, it will continue to move vertically downward (in the absence of preferred lateral routes of migration) until reaching the capillary fringe area or a relatively impermeable barrier if one is located above the capillary fringe. At this point, the fuel (liquid phase) will tend to spread throughout the capillary fringe and the transformation process will continue with the dissolution of hydrocarbons into ground water (dissolved phase). An evaluation of the relationship between contaminated media and exposure pathways at the project site is summarized in Table 3.1.

Receptors may be potentially exposed to the hydrocarbons found in the soil primarily through inhalation of volatilized compounds and dermal contact with soil at hydrocarbon contamination sites. Based on laboratory test results, petroleum contamination is present in near-surface soil at the project site. Exposure to these soils is contingent upon site disturbance via construction or remediation activities. In the event that soil remediation is required, there may be some inhalation exposure from volatilization of the hydrocarbons found in the soil. Volatile components will be released and the potential for exposure will occur at this time. Dermal exposure from soil contact by personnel may also occur if remediation activities include excavation. Since this is an occupational exposure, the receptor analysis for these exposure pathways should be considered as part of the site remediation design plan.

Exposure via ingestion most commonly occurs from consumption of drinking water obtained from contaminated wells or contaminated public water supplies. According to our review of available information, the nearest operational water supply well is located approximately 1000 feet northeast of the project site. Since our assessment indicates that the direction of ground-water flow within the surficial aquifer is to the east, the potential for exposure to drinking-water wells from contamination originating from the subject site appears to be minimal.

Structural Receptors

Buildings in the vicinity of TC-341 appear to be slab-on-grade types of structures. A 6-inch water main line is located approximately 30 feet to the west of the UST and also approximately 300 feet east of the UST. Due to the close proximity of the water line to the west, and the line to the east being hydraulically down-gradient, they may be considered as possible receptors.

Hydrologic Receptors

The nearest surface water body to the site is Brinson Creek which is located approximately 1000 feet (0.4 miles) to the east-northeast. Marsh areas associated with Brinson Creek are located approximately 800 feet to the east-northeast of the site (USGS, 1971).

4.0 SOILS INVESTIGATION

4.1 Site Topography

The project area is at an elevation of approximately 16 to 17 feet above mean sea level (USGS, 1971). The project area is relatively flat, gently sloping to the east towards Brinson Creek. The area surrounding the tank system of TC-341 consists of open, grassed area to the north, east and west, with Buildings TC-341 and TC-342 located south-southeast.

4.2 Regional Geology

The study area is located within the Lower Coastal Plain Soil System (Wiscomico and Talbot System) and the Coastal Plain/Castle Hayne Limestone hydrologic area. The sediments of the Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone (LeGrand, 1959). These sediments are layered in interfingering beds and lenses that gently dip and thicken to the east and include ten aquifers and nine confining units. In the Camp LeJeune area, the sediments are about 1,500 feet thick and overlie igneous and metamorphic basement rocks. These sediments were deposited in marine or near-marine environments (Brown and others, 1972).

A brief summary of the geologic/hydrogeologic setting at the Building TC-341 site is provided in the CSA Workplan (Appendix A). In general, downward movement of ground water is obstructed by the presence of clay layers in Coastal Plain formations and consequently most of the ground-water recharge migrates laterally toward discharge areas through the surficial aquifer (Heath, 1980). Further details of regional geologic/hydrogeologic characteristics are provided in Section 5.1 of this report.

4.3 Site Soils and Geology

Drilling, soil sampling and monitoring well installation activities were initiated and completed in March, 1994. Locations of these borings/wells, shown in Drawing 4.1, were located in the field based on analysis of previous studies of the site.

All drilling was accomplished using the hollow stem auger (HSA) technique (ASTM D-1452). Augers of 6.25-inch inner diameter (I.D.) were used to advance the boreholes. Prior to work, all down-hole drilling equipment was steam-cleaned. Soil cuttings were disposed of on-site in a roll-off box provided by Waste Industries, Inc. for off-site disposal. Soil samples were collected from each of the boreholes. Soil samples collected for classification during the drilling operation were generally obtained at depths of 0.0 to 1.5 feet, 3.5 to 5.0 feet, 8.5 to 10.0 feet and on 5-foot centers thereafter to boring termination. Boring depths ranged from 13.0 feet BLS for Type II monitoring wells, to 32 feet BLS for Type III monitoring wells. Soil samples were collected with a 24 inch long, 1.375-inch I.D. (2-inch outer diameter) split spoon sampler. Split spoon sampling was performed in general accordance with ASTM D-1586 and the number of blows required to drive the sampler each six-inch increment was recorded on the field boring log. The soil samples were identified in the field using visual/manual techniques described in ASTM D-2487 and ASTM D-2488. The soil was classified in accordance with the Unified Soil Classification System and a record of each test boring was produced. The soil test boring records are presented in Appendix B. Representative portions of each sample were placed in pre-labeled plastic bags and sealed for subsequent headspace testing.

Near-surface soils within 6.0 to 11.0 feet BLS generally consist of fine silty sands with occasional clayey fine sands and fine sandy clay lenses. Beneath these surficial materials, soils generally consist of slightly silty to silty fine to coarse sands to a depth of approximately 32 feet. This type of deposit appears to comprise much of the surficial aquifer at the subject site. Soils classified in the field as gray slightly silty fine sand with generally lower penetration resistance were encountered at depths of approximately 13.5 to 15.0 feet in borings completed for both the Type II wells and Type III wells. Sampling was stopped at approximately 30 feet in borings for monitoring wells MW-9 and MW-15. Moist soil conditions were generally encountered at depths of approximately 4 to 6 feet BLS.

Two cross-sections, the locations of which are shown in Drawing 4.2, were developed for the site to present lithologic interpretations. The cross-sections, as developed from the boring records, are illustrated in Drawings 4.3 and 4.4.

Representative soil samples collected at depths of 8.5 to 10.0 feet and 20.0 to 21.5 feet BLS from MW-7 and MW-9, respectively, were submitted for laboratory grain-size distribution tests. The results of the grain-size distribution tests, presented in Appendix C, reveal that the samples collected from 8.5 to 10.0 feet contained 59.0% fine to medium sand and 41.0% silt and clay, and that the sample from 20.0 to 21.5 feet contained 85.5% sand, 14.2% silt and clay, and .3% gravel.

4.4 Soil Contamination

The soil investigation activities were monitored with an HNu Photoionization Detector (PID) calibrated to 99.6 percent isobutylene, to determine the relative quantities of total volatile ionizable compounds in the borehole, in ambient air, and in the headspace of individual soil sample containers. Values recorded with the PID are qualitative only and are not directly comparable to actual laboratory analytical results. However, a PID is useful in providing a relative indication of the presence of total volatile ionizable compounds in soil samples.

Soil samples for headspace analysis were collected from each boring according to the following procedure:

- The decontaminated split-spoon sampler was driven to the desired depth interval.
- The split-spoon sampler was retrieved and immediately opened. A small portion of the sample was quickly removed from the split-spoon sampler and placed into a pre-labeled, airtight, plastic bag in a warm location. The remainder of the sample was placed in a second airtight, pre-labeled, laboratory container and stored on ice. Sample handling was executed carefully so as to minimize the loss of potential trace gases.
- At the conclusion of each sampling event, the headspace gas in the bags was measured for total ionizable compounds with the HNu, and the peak value was recorded for each bag sample.

Headspace sampling results are presented in Table 4.1. Results show elevated readings in soil samples collected from a depth of 3.5 to 15.0 feet BLS at location MW-14 and from a depth of 3.5 to 30.0 feet BLS at location MW-15. Results also show a slightly elevated reading in the 13.5 to 15.0 foot soil sample at location MW-16.

Two soil samples were retained from each soil boring for either on-site or off-site laboratory analysis. The on-site laboratory is owned and operated by Geochem Laboratories, Inc. of Morrisville, North Carolina. All off-site samples were submitted to Law Environmental National Laboratories in Pensacola, Florida. Approximately the first fifty percent of soil samples collected from the monitoring well soil borings were packed on ice and submitted to the on-site lab to aid in locating the remaining borings. The remaining fifty percent of the soil samples were placed in a cooler, packed on ice and shipped to the off-site laboratory. The distribution of samples submitted to each respective laboratory is shown in Table 4.2. The soil samples submitted to both the on-site and off-site laboratories were analyzed for total petroleum hydrocarbons (TPH) according to EPA preparation/testing Methods 5030/8015 (volatile fraction), 3550/8015 (semi-volatile fraction) and 9071 (oil and grease). Selected soil samples were also analyzed for pH, flashpoint, TCLP metals and total lead. Custody of the samples was maintained by Law Engineering field staff until shipment or delivery to the on-site laboratory.

Chemical testing results for the soil samples collected are summarized in Table 4.3. The laboratory testing indicated the presence of detectable TPH-gasoline in soil samples collected at a depth of 3.5 to 5.0 feet at locations MW-14 and MW-15. The concentration of 4100 mg/Kg in MW-14 and 200 mg/Kg in MW-15 for TPH-gasoline at these locations is well above the State's action level of 10 mg/Kg. Laboratory testing also indicated the presence of detectable TPH-diesel in soil samples collected at a depth of 3.5 to 5.0 feet at locations MW-14 and MW-15. Concentration levels of 800 and 490 mg/Kg, which are above the State's action level of 40 mg/Kg for TPH-diesel, were detected respectively. Also, a concentration level of 11 of TPH diesel was detected in MW-11 and MW-17 at a depth of 0.0 to 1.5 feet. This level is below the State's action level of 40 mg/Kg. Drawing 4.5 shows the distribution of TPH results within the vadose zone soils at the site. Headspace analysis of soil samples analyzed by the on-site and off-site laboratories generally show a good correlation.

Laboratory testing indicated the presence of TCLP barium in soil samples collected from MW-11 and MW-14 at a depth of 3.5 to 5.0 feet at a concentration of 400 ug/L and 250 ug/L respectively, which are below the State's action level of 100,000 ug/L.

Laboratory results indicate that the pH of site soils falls generally in a range between 5.53 to 7.48 suggesting that the soils are slightly acidic to near neutral. TCLP metals barium, chromium, and cadmium were detected in two samples at concentrations below TCLP limits for the respective metals. Results of flashpoint analyses suggest that site soils are not flammable.

5.0 GROUND-WATER INVESTIGATION

5.1 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 evaporates 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).

5.2 Site Hydrogeology

Site specific data used to characterize the local hydrogeology was obtained through the installation of ground-water monitoring wells. A total of twelve Type II and two Type III ground-water monitoring wells were constructed during this investigation utilizing the materials and installation procedures described in the Workplan (Appendix A). These specifications included decontamination of the drilling equipment and well construction materials with a pressure steam cleaning unit. All monitoring well heads are protected by concrete pads and well head covers. Monitoring well installation details for the Type II and Type III wells are included in Appendix D.

Depths to ground water were measured in all monitoring wells on March 30, 1994. The measurements are included on the Monitoring Well Casing and Water Elevation Worksheets contained in Appendix E. Elevations of the monitoring wells installed by Law Engineering were determined by McKim and Creed Engineers and are also included in the Worksheets contained in Appendix E.

Based on measured ground-water elevations in the monitoring wells, a water-table elevation contour map was constructed to determine ground-water flow direction as shown in Drawing 5.1. A horizontal hydraulic gradient of approximately 0.006 within the surficial aquifer was determined from this map (see Appendix F). In general, ground-water within the surficial aquifer flows to the east toward Brinson Creek, which discharges into the New River. The stabilized ground-water table at the time of our field work appears to have been between 10.50 feet and 13.50 feet BLS within the area of investigation. The average hydraulic conductivity of the surficial aquifer as determined through recovery tests is estimated to be approximately 1.5 feet per day (see Appendix G).

As indicated by a comparison of water-level elevations in the following paired Type II and Type III monitoring wells: MW-9 (screened from 27.0 to 32.0 feet BLS) and MW-10 (screened from 3.0 to 13.0 feet BLS); MW-14 (screened from 3.0 to 13.0 feet BLS) and MW-15 (screened from 25.0 to 30.0 feet BLS); the direction of ground water flow within the surficial aquifer appears have a slight downward component in the vicinity of both pairs locations.

5.3 Extent of Free Product

In conformance with regulations promulgated by the North Carolina Department of Environment, Health and Natural Resources, the estimated extent of free product was delineated for the site. Free product is defined as a regulated substance that is present as a non-aqueous phase liquid (e.g., liquid not dissolved in water).

Type II monitoring wells were constructed to allow for detection of free product in the surficial aquifer. As indicated on the Monitoring Well Casing and Water Elevation Worksheet presented in Appendix E, free product thicknesses were measured in two on-site wells during this investigation. Free product was detected in monitoring wells MW-1 and MW-2, which were installed prior to this investigation. The estimated extent of free product is shown in Drawing 5.2.

5.4 Dissolved Ground-Water Contamination

Ground-water samples were collected from each of the fourteen newly installed monitoring wells. Prior to sampling, personnel donned laboratory grade gloves. These gloves were replaced after sampling each well to minimize the potential for cross-contamination. Prior to well sampling, the depths to ground water were determined using an electronic water-level meter. The distance from the measuring point to each respective depth was measured and recorded. The data collected and observations made were recorded on the Monitoring Well and Sampling Field Data Worksheets (Appendix H).

Approximate volumes of water removed during development and observations of turbidity are listed in Table 5.1. The development water, approximately 166 gallons total, was temporarily containerized on-site and then taken off-site to P & W Oil Company, Inc. in Leland, North Carolina.

All monitoring wells were purged prior to sample collection to remove stagnant water from the well casing and sand pack in an effort to collect samples representative of the water quality in the surficial aquifer. Each well was purged using a pre-cleaned teflon bailer. Specific conductance, pH, and water temperature were measured and recorded throughout the purging process. Well purging continued until three standing well volumes were removed and indicator parameters had stabilized. Water samples were then collected and immediately decanted gently from the bailer into pre-labeled sample containers. These containers were sealed, and stored in chilled coolers. Custody of the samples was maintained by Law Engineering field staff until samples were relinquished for laboratory analysis. Water generated during the well purging and development process was temporarily containerized on-site and then disposed of at an off-site disposal facility.

Ground-water samples were analyzed for purgeable aromatic hydrocarbons according to EPA Method 602 for monitoring wells MW-1, MW-4, MW-7, MW-8 and MW-10. Samples from the monitoring wells were submitted to both the on-site and off-site laboratories for analysis. Table 5.2 shows the distribution of samples submitted to each of the laboratories. A summary of ground-water analytical results is presented in Table 5.3. Results suggest that dissolved phase purgeable aromatic hydrocarbons are present in the upper portion of the surficial aquifer.

The concentrations of constituents detected within shallow ground water were plotted on site maps to illustrate their spatial distribution in the vicinity of the site. Maps showing the extent of free product detected and concentrations of benzene, toluene, ethylbenzene, total xylenes, methyl-tertiary-butyl ether (MTBE), and total polynuclear aromatic hydrocarbon (PAH) compounds are presented in Drawings 5.2 through 5.8 respectively. Drawings 5.2, 5.3, 5.4, 5.5, 5.6 and 5.7 illustrate that the horizontal and vertical extent of free product, benzene, toluene, ethylbenzene, total xylenes and MTBE has been defined by the sampling network. Similarly, Drawing 5.8 suggests that the horizontal and vertical extent of total PAH compounds within shallow ground water in the vicinity of the subject UST has also been defined adequately by the network.

The distribution of of PAH compounds in groundwater shown in Drawing 5.8 illustrates that the extent of PAH contamination has been defined to the north, south and west of the subject tank system, and to levels of 10's of a ug/l, 300 feet downgradient of that tank system.

Laboratory testing of the ground-water sample collected from MW-14 indicates the presence of total PAH compounds at a concentration of 5240 ug/L. MW-14 is located approximately 350 feet east of the leaking UST. Concentrations of only 14.6 ug/L were detected in MW-8. In light of these data and the fact that other potential contaminant sources have been identified downgradient of the subject site, it does not appear that the contamination found in MW-14 is solely a result of the TC-341 UST.

5.5 Vertical Gradient Determinations

Ground water exhibits both horizontal and vertical components of flow within an aquifer. The hydraulic gradient is the difference in hydraulic head along a flow path divided by the distance between those points. The vertical component of the gradient may be either upward or downward within the aquifer. At the project site there are two well clusters which pair a shallow Type II monitoring well with a deeper Type III monitoring well. These well clusters are identified below:

Shallow Well	Deep Well
MW-10	MW-9
MW-14	MW-15

The vertical gradient is calculated by first determining the difference in the static water level elevations at each well. Second, the relative elevation of the middle of the screened interval is determined for each well. Finally, the difference in the static water-level elevations is divided by the difference in the midscreen elevations. This value is arbitrarily assigned a positive value if the ground water is moving vertically downward and a negative value if the ground water is moving vertically upward. Vertical gradients determined for the site and values used to calculate the gradient are summarized in Table 5.4. According the these data, the vertical gradient at both locations is downward.

5.6 Rate of Contaminant Migration

The rate at which contaminants migrate through the subsurface is affected by several geohydrochemical processes including molecular diffusion, mechanical mixing, sorption-desorption, ion-exchange, hydrolysis and biodegradation. Because the resources involved in attempting to model the effects of these processes at the project site are significant, we have chosen to apply a relatively simple analytical technique (USEPA, 1985) with which to arrive at a conservative (greater than anticipated) estimate of contaminant migration rates at the site. The analytical technique takes into account only sorption-desorption of the contaminant constituent (expressed in terms of the "retardation factor") and the average linear ground-water flow velocity at the site.

For purposes of these calculations, we used the average hydraulic conductivity of the surficial aquifer as determined by on-site recovery tests (1.5 feet/day), and the horizontal hydraulic gradient determined to be approximately 0.006. If an effective porosity of 20% is assumed for the surficial aquifer, a seepage velocity of approximately 0.05 feet per day can be determined using Darcy's Law. The approximate rates of movement for petroleum compounds detected within the surficial aquifer would likely be slower than the ground-water seepage rate due to reasons discussed previously. Below is the expected range of contaminant movement rates at the site.

COMPOUND	RATE Vc (Feet/Day)
MTBE	0.04
Benzo(a)anthracene	10^{-5}

It is important to note that these migration rates are only gross estimates and may vary considerably from actual field migration rates.

6.0 QUALITY CONTROL PROCEDURES

6.1 Equipment Decontamination

Quality control procedures for equipment handling and decontamination are detailed in the Workplan (Appendix A). Decontamination of the drilling equipment was performed at the wash rack located at Building FC200 and Building TC-341, where waste soil and water were collected and containerized on-site for subsequent proper disposal.

6.2 Sample Collection and Shipment

Details of quality control procedures for sample collection, handling and shipment are included in the CSA Workplan (Appendix A). To provide checks on the integrity and quality of the field sampling program performed at the project site, two quality control measures were employed. First, equipment rinse blanks were submitted to the laboratory for evaluation of procedures used to decontaminate the Teflon sampling bailers. Second, trip blanks were submitted to the laboratory during shipment of the monitoring well samples to perform checks on the integrity of the sample containers and ascertain whether contaminants may have entered the samples during transport to and from the job site. Laboratory quality controls included the use of lab blanks throughout the analytical procedures to check for laboratory induced contamination.

Analysis of the rinse blank collected during the monitoring-well sampling for polynuclear aromatic hydrocarbon compounds did exhibit the presence of such compounds in excess of the laboratory detection limits. This result appears to be inconsequential however, because three of the five detected compounds were not detected in any other samples. Further, the two that were detected in samples from monitoring wells were one to two orders of magnitude greater in concentration than those detected in the rinse blank. It is likely that the rinse blank sample was contaminated by an external source during collection. Duplicate sample analysis produced results that were generally consistent.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon our assessment activities at the site, a spatial distribution of petroleum-hydrocarbon contamination at levels exceeding regulatory standards exists within ground water at the site. Preliminary recommendations describe additional activities that will be needed to meet remaining regulatory requirements.

7.1 Overview and Objectives of Soil and Ground-water Remediation

7.1.1 Soil

Results of this investigation indicate that the extent of vadose soil contamination has been defined and occurs within the immediate vicinity of the tank. Protection of public health and ground-water quality are the primary reasons for soil remediation at sites with elevated concentrations of TPH. As discussed in Section 3.0 of this report, the potential for exposure to contaminated soil at the project site is minimal as long as the subsurface remains undisturbed. However, guidelines for remediation of soil contaminated by petroleum have been established by the Groundwater Section of the Division of Environmental Management, DEHNR (1993).

Within these guidelines, the Groundwater Section has set "action levels" of 10 mg/Kg for soils contaminated with low boiling point hydrocarbons and 40 mg/Kg for soils contaminated with medium boiling point hydrocarbons in contact with ground water. Where petroleum contaminated soil is not in contact with the shallow ground water and other, specific conditions apply, the final clean-up levels for site soils may range up to 300 mg/Kg and 1200 mg/Kg for low and medium boiling point hydrocarbons respectively. Because free product is present on the water table in the vicinity of the UST system, and because TPH was not detected in unsaturated soils at the remaining boring/monitoring well locations, completion of a Site Sensitivity Evaluation was not required. Therefore, the objectives for remediation of contaminated soil at the project site should focus on 1) eliminating the adsorbed hydrocarbons as an ongoing source of ground-water contamination through leaching and desorption and 2) complying with NCDEHNR guidelines which require remediation of all soil containing petroleum hydrocarbons in excess of DEM action levels.

7.1.2 Ground Water

The results of this investigation indicate that ground water flows primarily to the east and that contamination has occurred in mainly the upper portion of the surficial aquifer.

The necessity of remediation efforts designed to restore ground-water quality is often not easily quantified. The decision ultimately rests upon regulatory requirements, the measured and/or perceived present and future utility of the ground-water resource, the risks associated with the potential exposure to the contaminants, and the availability of resources with which to implement and operate a ground-water restoration project. Obviously, remediation is warranted in a situation where the risk to public health or welfare is unavoidable and unacceptable as a result of exposure to ground-water contaminants. As indicated in Section 3.0 and Table 3.1 of this report, present exposure to ground-water contaminants in the vicinity of the project site is considered unlikely.

With respect to regulatory requirements, the North Carolina Environmental Management Commission (EMC) has adopted maximum allowable concentrations for contaminant constituents in ground water. The maximum regulatory concentration for compounds detected in ground water beneath the site are included in Table 5.3. For compounds which do not have a numerical standard, a petition may be filed with the North Carolina Division of Environmental Management (DEM) in order to establish such a standard. Otherwise, a maximum allowable concentration for the compound not listed is equal to its laboratory detection limit. As indicted in Table 5.3, Law Engineering has documented the occurrence of several constituents at levels which exceed the maximum allowable concentrations for at the project site.

At sites where ground-water standards have been exceeded, rules adopted by the EMC and enforced by DEM require that a corrective action plan for the restoration of ground-water quality be prepared. The feasibility and justification for alternative remedial options ranging from natural attenuation (no action) to active remediation are addressed in the corrective action plan with the addition of limited confirmation sampling. This comprehensive site assessment will provide the data needed for preparation of such a plan.

7.2 Conclusions

Based upon the results of our investigation, petroleum related contamination is present within soils and ground water within the area of investigation. The majority of soil contamination appears to occur within the immediate vicinity of the UST subject system. Ground-water contamination was detected primarily in the upper portion of the surficial aquifer.

The extent of benzene, ethylbenzene, toluene, total xylenes, methyl-tertiary-butyl ether and polynuclear aromatic hydrocarbons within site ground water has been adequately defined by the sampling network used in this study. Elevated concentrations of PAH compounds at the furthest downgradient well location suggest that other petroleum sources located east of TC-341 have contributed petroleum compounds to the shallow ground water in that area.

Results of this assessment suggest that the majority of soil and ground-water contamination originating from the tank system at Building TC-341 has been adequately defined for the purposes of preparing a Corrective Action Plan.

7.3 Recommendations

Based on our assessment of the subject site, soil and ground water both indicated the presence of compounds characteristic of fuel oil that leaked from the UST system at TC-341 and possibly gasoline or Jet fuel from the petroleum source located east of TC-341. The presence of free product in ground-water coupled with elevated concentrations of petroleum constituents requires additional measures to satisfy groundwater requirements set forth by the state.

Our recommendations are as follows:

- Initiate free product recovery activities in the vicinity of the TC-341 UST system.
- Provide a copy of this comprehensive site assessment to the State for their review and files.
- Perform additional investigation to determine the limits of soil and ground-water contamination to the east of Building TC-341.
- Begin preparation of a Corrective Action Plan.

8.0 REFERENCES

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TABLES

TABLE 2.1
CONTAMINANT SOURCE INVENTORY
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

SOURCE ID NO.	PRODUCT TYPE	INSTALLATION DATE	SIZE OF TANK (GAL.)	STATUS
TC-341 TANK	NUMBER 6 HEATING OIL	1941	UNKNOWN	ABANDONED IN PLACE
TC341 TANK FUEL SUPPLY LINE	NUMBER 6 HEATING OIL	1941	6" DIAMETER	ABANDONED IN PLACE
BUILDING NO. TC-480	NUMBER 2 FUEL OIL	1976	550 GALLON UST	ACTIVE
BUILDING NO. TC-474	WASTE OIL	1946	550 GALLON	ABANDONED
FUEL TANK FARM	GASOLINE, DIESEL, KEROSENE	1940'S	5-15,000 GALLON TANKS	ACTIVE
GAS STATION BUILDING 341	GASOLINE, DIESEL	UNKNOWN	UNKNOWN	DEMOLISHED

NOTE:

Underground lines associated with these tanks, the fuel farm above ground tanks, and the oil-water separator located southeast of the fuel farm are also potential contaminant sources.

TABLE 3.1
WELL INVENTORY SUMMARY
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

USGS WELL NO.	MCB WELL NO.	TOTAL WELL DEPTH (FT)	SCREENED INTERVAL (FT)	CASING DIAMETER (INCH)	APPROXIMATE DISTANCE FROM BUILDING TC-341 (FT)	WELL USAGE
3444300772729.1	TC-104	182.0′	107′-182′ (OPEN HOLE)	10.0"	2000.0′	ABANDONED
3444280772729.1	TC-100	67.0′	OPEN HOLE	18.0"	1950.0′	ABANDONED
3444120772755.1	TC-202	80.0′	35′-80′	8.0"	1950.0′	ABANDONED
3444120772755.2	TC-325	--	--	--	1950.0′	ABANDONED
3444070772728.1	TC-502	184.0′	110′-184′ (OPEN HOLE)	10.0"	1500.0′	WATER SUPPLY
3444180772729.1	NC-52	70.0′	25′-66′ (OPEN HOLE)	--	1700.0′	WATER SUPPLY
3444050772728.1	TC-600	70.0′	48′-70′	8.0"	1800.0′	WATER SUPPLY
3443560772727.1	TC-700	76.0′	27.5′-76′ (OPEN HOLE)	18.0"	2600.0′	WATER SUPPLY
3444250772707.1	T-15	477.0′	OPEN TEST HOLE	--	1000.0′	WATER SUPPLY

-- Not Available

TABLE 3.2
SUMMARY OF EXPOSURE PATHWAYS
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

CONTAMINATED MEDIUM	INGESTION (EATING)	INGESTION (DRINKING)	INHALATION	ADSORPTION
Free Product	NA	Exposure Unlikely (1)	NA	Exposure Unlikely (1)
Soil	Contingent Exposure (2)	NA	NA	Contingent Exposure (2)
Ground Water	Exposure Unlikely (3)	Exposure Unlikely (3)	NA	Exposure Unlikely (3)
Surface Water	Exposure Unlikely (4)	Exposure Likely (4)	NA	Exposure Likely (4)
Vapor	NA	NA	Exposure Unlikely (5)	NA

NOTES:

NA	Not Applicable
(1)	Free product detected in surficial waters; water supply wells draw from Castle Hayne aquifer.
(2)	Potential for exposure only if subsurface below approximately 1.0 foot BLS is disturbed.
(3)	Via use of MCAS water supply lines that extend through the project area for drinking, cooking and bathing.
(4)	Preliminary ground-water sampling results indicated that petroleum constituents may extend to Brinson Creek that may carry constituents to the New River.
(5)	Limited assessment indicates sunsurface vaults, manways, or other exposure routes in vicinity of known soil/product contamination.

TABLE 4-1 (Page 1 of 2)
SUMMARY OF HEADSPACE ANALYSIS
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (FT.)	PID READING (PPM)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-4 SS1	0.0′-1.5′	ND	✓
MW-4 SS2	3.5′-5.0′	ND	✓
MW-4 SS3	8.5′-10.0′	ND	
MW-4 SS4	13.5′-15.0′	ND	
MW-5 SS1	0.0′-1.5′	ND	✓
MW-5 SS2	3.5′-5.0′	ND	✓
MW-5 SS3	8.5′-10.0′	ND	
MW-5 SS4	13.5′-15.0′	ND	
MW-6 SS1	0.0′-1.5′	ND	✓
MW-6 SS2	3.5′-5.0′	ND	✓
MW-6 SS3	8.5′-10.0′	ND	
MW-6 SS4	13.5′-15.0′	ND	
MW-7 SS1	0.0′-1.5′	ND	✓
MW-7 SS2	3.5′-5.0′	ND	✓
MW-7 SS3	8.5′-10.0′	ND	
MW-7 SS4	13.5′-15.0′	ND	
MW-8 SS1	0.0′-1.5′	ND	✓
MW-8 SS2	3.5′-5.0′	ND	✓
MW-8 SS3	8.5′-10.0′	ND	
MW-8 SS4	13.5′-15.0′	ND	
MW-9 SS1	0.0′-1.5′	ND	✓
MW-9 SS2	3.5′-5.0′	ND	✓
MW-9 SS3	8.5′-10.0′	ND	
MW-9 SS4	13.5′-15.0′	ND	
MW-9 SS5-A	18.5′-20.0′	ND	
MW-9 SS5-B	20.0′-21.5′	ND	
MW-9 SS6	23.5′-25.0′	ND	
MW-9 SS7	28.5′-30.0′	ND	
MW-10 SS1	0.0′-1.5′	ND	✓
MW-10 SS2	3.5′-5.0′	ND	✓
MW-10 SS3	8.5′-10.0′	ND	
MW-10 SS4	13.5′-15.0′	ND	

ND None Detected

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TABLE 4.1 (Page 2 of 2)
SUMMARY OF HEADSPACE ANALYSIS
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (FT.)	PID READING (PPM)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-11 SS1	0.0'-1.5'	ND	✓
MW-11 SS2	3.5'-5.0'	ND	✓
MW-11 SS3	8.5'-10.0'	ND	✓
MW-11 SS4	13.5'-15.0'	ND	
MW-12 SS1	0.0'-1.5'	ND	✓
MW-12 SS2	3.5'-5.0'	ND	✓
MW-12 SS3	8.5'-10.0'	ND	✓
MW-12 SS4	13.5'-15.0'	ND	
MW-13 SS1	0.0'-1.5'	ND	✓
MW-13 SS2	3.5'-5.0'	ND	✓
MW-13 SS3	8.5'-10.0'	ND	✓
MW-13 SS4	13.5'-15.0'	ND	
MW-14 SS1	0.0'-1.5'	ND	✓
MW-14 SS2	3.5'-5.0'	40	✓
MW-14 SS3	8.5'-10.0'	40	✓
MW-14 SS4	13.5'-15.0'	32	
MW-15 SS1	0.0'-1.5'	ND	✓
MW-15 SS2	3.5'-5.0'	42	✓
MW-15 SS3	8.5'-10.0'	60	✓
MW-15 SS4	13.5'-15.0'	17	✓
MW-15 SS5	18.5'-20.0'	2	
MW-15 SS6	23.5'-25.0'	9	
MW-15 SS7	28.5'-30.0'	10	✓
MW-16 SS1	0.0'-1.5'	ND	✓
MW-16 SS2	3.5'-5.0'	ND	✓
MW-16 SS3	8.5'-10.0'	ND	✓
MW-16 SS4	13.5'-15.0'	8	
MW-17 SS1	0.0'-1.5'	ND	✓
MW-17 SS2	3.5'-5.0'	ND	✓
MW-17 SS3	8.5'-10.0'	ND	
MW-17 SS4	13.5'-15.0'	ND	

ND None Detected

TABLE 4.2
SUMMARY OF ON-SITE/OFFSITE LABORATORY DISTRIBUTION
SOIL SAMPLES
MARINE CORPS AIR STATION
BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

	ANALYSIS						
	EPA Method 5030 (Gasoline)	EPA Method 3550 (Diesel)	EPA Method 9071 (Oil & Grease)	EPA Method 1311 (TCLP Metals)	EPA Method 7470 (Mercury)	FLASH POINT	pH
MW-4 SS1	X	X					
MW-4 SS2	X	X					
MW-5 SS1	X	X					
MW-5 SS2	X	X					
MW-6 SS1	X	X					
MW-6 SS2	X	X					
MW-7 SS1	X	X					
MW-7 SS2	X	X					
MW-8 SS1	X	X					
MW-8 SS2	X	X					
MW-9 SS1	X	X					
MW-9 SS2	X	X					
MW-10 SS1	X	X					
MW-10 SS2	X	X					
MW-10 SS2*	X	X					
MW-11 SS1	O	O					
MW-11 SS2	O	O		O	O	O	O
MW-11 SS3			O				
MW-12 SS1	O	O	O			O	
MW-12 SS2	O	O				O	O
MW-12 SS3			O				
MW-13 SS1	O	O				O	O
MW-13 SS2	O	O					O
MW-13 SS3			O				
MW-14 SS1	O	O				O	O
MW-14 SS2	O	O	O	O	O	O	
MW-14 SS3			O				
MW-15 SS1	O	O					
MW-15 SS2	O	O				O	O
MW-15 SS3						O	O
MW-15 SS4			O				
MW-15 SS7			O				
MW-16 SS1	O	O					O
MW-16 SS2	O	O				O	O
MW-16 SS3			O				
MW-17 SS1	O	O	O			O	O
MW-17 SS2	O	O					
MW-17 SS2*	O	O					

X = On-Site Laboratory Analysis
O = Off-Site Laboratory Analysis

* Duplicate Sample

TABLE 4.3 (l of 2)
SUMMARY OF LABORATORY ANALYTICAL RESULTS
SOIL SAMPLES
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

SAMPLE LOCATION		LABORATORY RESULTS					
		TPH-GASOLINE (mg/Kg)	TPH-DIESEL (mg/Kg)	TPH-OIL & GREASE (mg/Kg)	TCLP-METALS (ug/l)	FLASH POINT (DEGREES F)	pH
MW-4 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-4 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-5 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-5 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-6 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-6 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-7 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-7 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-8 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-8 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-9 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-9 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-10 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-10 SS2	3.5'-5.0'	ND	100	--	--	--	--
MW-10 SS2*	3.5'-5.0'	ND	ND	--	--	--	--
MW-11 SS1	0.0'-1.5'	ND	11	--	--	--	--
MW-11 SS2	3.5'-5.0'	ND	ND	--	400	NF	6.52
MW-11 SS3	8.5'-10.0'	--	--	ND	--	--	--
MW-12 SS1	0.0'-1.5'	ND	ND	ND	--	NF	--

ND Not detected; see laboratory reports for applicable detection limit
NF No Flash
-- Not analyzed
* Duplicate Sample
Shaded Area = Concentrations detected above NC soil remediation guidelines

NC Action Level for:
Low Boiling Point Hydrocarbons (Gasoline) = 10 mg/Kg
Medium Boiling Point Hydrocarbons (Diesel) = 40 mg/Kg
High Boiling Point Hydrocarbons (Oil & Grease) = 250 mg/Kg

TABLE 4 of 2)
SUMMARY OF LABORATOR ALYTICAL RESULTS
SOIL SAMPLES
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

SAMPLE LOCATION		LABORATORY RESULTS					
		TPH-GASOLINE (mg/Kg)	TPH-DIESEL (mg/Kg)	TPH-OIL & GREASE (mg/Kg)	TCLP-METALS (ug/l)	FLASH POINT (DEGREES F)	pH
MW-12 SS2	3.5'-5.0'	ND	ND	--	--	NF	7.62
MW-12 SS3	8.5'-10.0'	--	--	ND	--	--	--
MW-13 SS1	0.0'-1.5'	ND	ND	--	--	NF	6.02
MW-13 SS2	3.5'-5.0'	ND	ND	--	--	--	5.93
MW-13 SS3	8.5'-10.0'	--	--	ND	--	--	--
MW-14 SS1	0.0'-1.5'	ND	ND	--	--	NF	7.48
MW-14 SS2	3.5'-5.0'	4100	800	ND	260	NF	--
MW-14 SS3	8.5'-10.0'	--	--	350	--	--	--
MW-15 SS1	0.0'-1.5'	ND	ND	--	--	--	--
MW-15 SS2	3.5'-5.0'	200	490	--	--	NF	5.53
MW-15 SS3	8.5'-10.0'	--	--	--	--	NF	5.53
MW-15 SS4	13.5'-15.0'	--	--	ND	--	--	--
MW-15 SS7	28.5'-30.0'	--	--	ND	--	--	--
MW-16 SS1	0.0'-1.5'	ND	ND	--	--	--	5.56
MW-16 SS2	3.5'-5.0'	ND	ND	--	--	NF	6.55
MW-16 SS3	8.5'-10.0'	--	--	ND	--	--	--
MW-17 SS1	0.0'-1.5'	ND	ND	11	--	NF	7.23
MW-17 SS2	3.5'-5.0'	ND	ND	--	--	--	--
MW-17 SS2*	3.5'-5.0'	ND	ND	--	--	--	--

ND Not detected; see laboratory reports for applicable detection limit
NF No Flash
-- Not analyzed
* Duplicate Sample
Shaded Area = Concentrations detected above NC soil remediation guidelines

NC Action Level for:
Low Boiling Point Hydrocarbons (Gasoline) = 10 mg/Kg
Medium Boiling Point Hydrocarbons (Diesel) = 40 mg/Kg
High Boiling Point Hydrocarbons (Oil & Grease) = 250 mg/Kg

DRAFT

DRAFT

TABLE 5.1
SUMMARY OF MONITORING WELL DEVELOPMENT
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

MONITORING WELL IDENTIFICATION NO.	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL.)
MW-1**	FREE PRODUCT IN WELL	
MW-2**	FREE PRODUCT IN WELL	
MW-3**	4	29.1
MW-4	4	10
MW-5	4	7.7
MW-6	4	6.9
MW-7	4	10
MW-8	4	7.2
MW-9	3	21.2
MW-10	4	10
MW-11	4	7.2
MW-12	4	7.4
MW-13	4	7.2
MW-14	4	3.5
MW-15	3	21.0
MW-16	4	7.4
MW-17	4	7.1

NOTES:

* (1) Clear; (2) Slight; (3) Moderate; (4) High
** Existing Wells

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TABLE 5.2
SUMMARY OF ON-SITE/OFF-SITE LABORATORY DISTRIBUTION
GROUND WATER SAMPLES (MONITORING WELLS)
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

	ANALYSIS			
	EPA Method 6010	EPA Method 602	EPA Method 610	EPA Method 7470
MW-1	O	X	X	O
MW-2			X	
MW-3			X	
MW-4	O	X	X	O
MW-5			X	
MW-6			X	
MW-7		X	X,O	
MW-8		X	O	
MW-9			O	
MW-10		X	X	
MW-11			X	
MW-12			X	
MW-13			O	
MW-14			O	
MW-15			O	
MW-16			O	
MW-17			O	
RINSE BLANK		X	X	
TRIP BLANK			O	

X = Sample analyzed at On-site laboratory
O = Sample analyzed at Off-site laboratory

TABLE 5.3 (of 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS
GROUND WATER SAMPLES (MONITORING WELLS)
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

PARAMETER	WELL #	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7**		N.C. GROUNDWATER STANDARDS
	SCREENED INTERVAL (FT.)	19.0'^{1}	20.0'^{1}	19.5'^{1}	3.0'-13.0'	3.0'-13.0'	3.0'-13.0'	3.0'-13.0'		
	DATE SAMPLED	3/22/94	3/22/94	3/22/94	3/16/94	3/22/94	3/22/94	3/16/94		
EPA METHOD 6010										
Arsenic		44	--	--	ND	--	--	--		50
Barium		390	--	--	590	--	--	--		2000
Cadmium		ND	--	--	11	--	--	--		5
Chromium		ND	--	--	31	--	--	--		50
Lead		ND	--	--	60	--	--	--		15
EPA METHOD 602										
Benzene		ND	--	--	ND	--	--	0.6		1
Toluene		ND	--	--	0.7	--	--	ND		1000
Ethylbenzene		4.0	--	--	ND	--	--	ND		29
Xylenes (Total)		1.8	--	--	ND	--	--	ND		530
Methyl tert-butyl ether (MTBE)		NA	--	--	NA	--	--	NA		200
EPA METHOD 610										
Acenaphthene		247	108	ND	ND	ND	ND	ND	ND	*
Anthracene		114	ND	ND	ND	ND	ND	ND	ND	*
Benzo (a) anthracene		ND	ND	ND	ND	ND	ND	ND	ND	*
Benzofluoranthenes		ND	ND	ND	ND	ND	ND	ND	ND	*
Chrysene		ND	ND	ND	ND	ND	ND	ND	ND	*
Fluoranthene		45.5	12.2	ND	ND	ND	ND	ND	ND	*
Fluorene		326	166	ND	ND	ND	ND	ND	ND	280
1-Methylnaphthalene		ND	ND	ND	ND	ND	ND	ND	ND	*
2-Methylnaphthalene		ND	ND	ND	ND	ND	ND	ND	ND	*
Naphthalene		214	457	ND	ND	ND	ND	ND	ND	21
Phenanthrene		ND	ND	ND	ND	ND	ND	ND	ND	210
Pyrene		133	138	ND	ND	ND	ND	ND	ND	*

DRAFT

All results are ug/l

Shaded Area = Concentrations detected above NC groundwater standards

* Maximun detection limit is equal to laboratory detection limit

** Split Sample; 610 analysis for sample done by both on-site and off-site laboratories

ND Not Detected; see laboratory reports for applicable detection limits

-- Sample not analyzed for this parameter

NA Not Analyzed; MTBE is not included in on-site laboratory EPA 602 analysis

NOTES:

[1] Indicates existing well depth

TABLE 5.3 of 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS
GROUND WATER SAMPLES (MONITORING WELLS)
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

PARAMETER	WELL #	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	N.C. GROUNDWATER STANDARDS
	SCREENED INTERVAL (FT.)	3.0'-13.0'	27.0'-32.0'	3.0'-13.0'	3.0'-13.0'	3.0'-13.0'	3.0'-13.0'	3.0'-13.0'	
	DATE SAMPLED	3/22/94	3/22/94	3/16/94	3/22/94	3/22/94	3/22/94	3/22/94	
EPA METHOD 6010									
Arsenic		--	--	--	--	--	--	--	50
Barium		--	--	--	--	--	--	--	2000
Cadmium		--	--	--	--	--	--	--	5
Chromium		--	--	--	--	--	--	--	50
Lead		--	--	--	--	--	--	--	15
EPA METHOD 602									
Benzene		ND	--	ND	--	--	--	--	1
Toluene		ND	--	ND	--	--	--	--	1000
Ethylbenzene		ND	--	ND	--	--	--	--	29
Xylenes (Total)		ND	--	1.6	--	--	--	--	530
Methyl tert-butyl ether (MTBE)		NA	--	NA	--	--	--	--	200
EPA METHOD 610									
Acenaphthene		ND	ND	19.3	ND	ND	ND	ND	*
Anthracene		3.1	ND	2.1	ND	ND	ND	620	*
Benzo (a) anthracene		ND	ND	ND	ND	ND	ND	ND	*
Benzofluoranthenes		ND	ND	ND	ND	ND	ND	ND	*
Chrysene		ND	ND	ND	ND	ND	ND	ND	*
Fluoranthene		ND	ND	ND	ND	ND	ND	ND	*
Fluorene		ND	ND	ND	ND	ND	ND	ND	280
1-Methylnaphthalene		1.4	ND	ND	ND	ND	ND	990	*
2-Methylnaphthalene		4.3	ND	ND	ND	ND	ND	2500	*
Naphthalene		ND	ND	32.6	ND	ND	ND	620	21
Phenanthrene		5.8	ND	8.9	ND	ND	ND	610	210
Pyrene		ND	ND	ND	ND	ND	ND	ND	*

All results are ug/l
Shaded Area = Concentrations detected above NC groundwater standards
* Maximun detection limit is equal to laboratory detection limit
** Split Sample; 610 analysis for sample done by both on-site and off-site laboratories
ND Not Detected; see laboratory reports for applicable detection limits
-- Sample not analyzed for this parameter
NA Not Analyzed; MTBE is not included in on-site laboratory EPA 602 analysis

NOTES:
[1] Indicates existing well depth

TABLE 3 of 3)
SUMMARY OF LABORA . ANALYTICAL RESULTS
GROUND WATER SAMPLES (MONITORING WELLS)
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

PARAMETER	WELL #	MW-15	MW-16	MW-17	RINSE BLANK	TRIP BLANK			N.C. GROUNDWATER STANDARDS
	SCREENED INTERVAL (FT.)	25.0'-30.0'	3.0'-13.0'	3.0'-13.0'					
	DATE SAMPLED	3/22/94	3/22/94	3/22/94	3/22/94	3/22/94			
EPA METHOD 6010									
Arsenic		--	--	--	--	--			50
Barium		--	--	--	--	--			2000
Cadmium		--	--	--	--	--			5
Chromium		--	--	--	--	--			50
Lead		--	--	--	--	--			15
EPA METHOD 602									
Benzene		--	--	--	ND	--			1
Toluene		--	--	--	ND	--			1000
Ethylbenzene		--	--	--	ND	--			29
Xylenes (Total)		--	--	--	ND	--			530
Methyl tert-butyl ether (MTBE)		--	--	--	NA	--			200
EPA METHOD 610									
Acenaphthene		ND	ND	ND	ND	ND			*
Anthracene		ND	ND	ND	ND	ND			*
Benzo (a) anthracene		ND	ND	ND	1.4	ND			*
Benzofluoranthenes		ND	ND	ND	2.0	ND			*
Chrysene		ND	ND	ND	1.0	ND			*
Fluoranthene		ND	ND	ND	0.7	ND			*
Fluorene		ND	ND	ND	ND	ND			280
1-Methylnaphthalene		ND	ND	ND	ND	ND			*
2-Methylnaphthalene		ND	ND	ND	ND	ND			*
Naphthalene		ND	ND	ND	ND	ND			21
Phenanthrene		ND	ND	ND	ND	ND			210
Pyrene		ND	ND	ND	0.9	ND			*

All results are ug/l

Shaded Area = Concentrations detected above NC groundwater standards

* Maximun detection limit is equal to laboratory detection limit

** Split Sample; 610 analysis for sample done by both on-site and off-site laboratories

ND Not Detected; see laboratory reports for applicable detection limits

-- Sample not analyzed for this parameter

NA Not Analyzed; MTBE is not included in on-site laboratory EPA 602 analysis

NOTES:

[1] Indicates existing well depth

TABLE 5.4
SUMMARY OF VERTICAL HYDRAULIC GRADIENT DETERMINATIONS
SITE ASSESSMENT REPORT
BUILDING TC-341
MARINE CORPS AIR STATION
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. 475-09183-01

	WELL PAIR			
	MW-10	MW-9	MW-14	MW-15
TOCE (ft.)	19.31	19.36	16.31	16.20
Approx. Mid-Screen Depth (ft.)	8.00	29.50	8.00	27.50
Approx. Mid-Screen Elevation (ft.)	11.31	-10.14	8.31	-11.30
SWLE (ft.)	12.46	12.04	10.79	10.51
ΔSWLE (ft.)	.42		.28	
ΔMid-Screen Elevation (ft.)	21.45		19.61	
Vertical Gradient	.02		.01	

NOTES:

TOCE	Top of Casing Elevation
SWLE	Static Water Level Elevation

Negative gradient indicates upward movement
Positive gradient indicates downward movement

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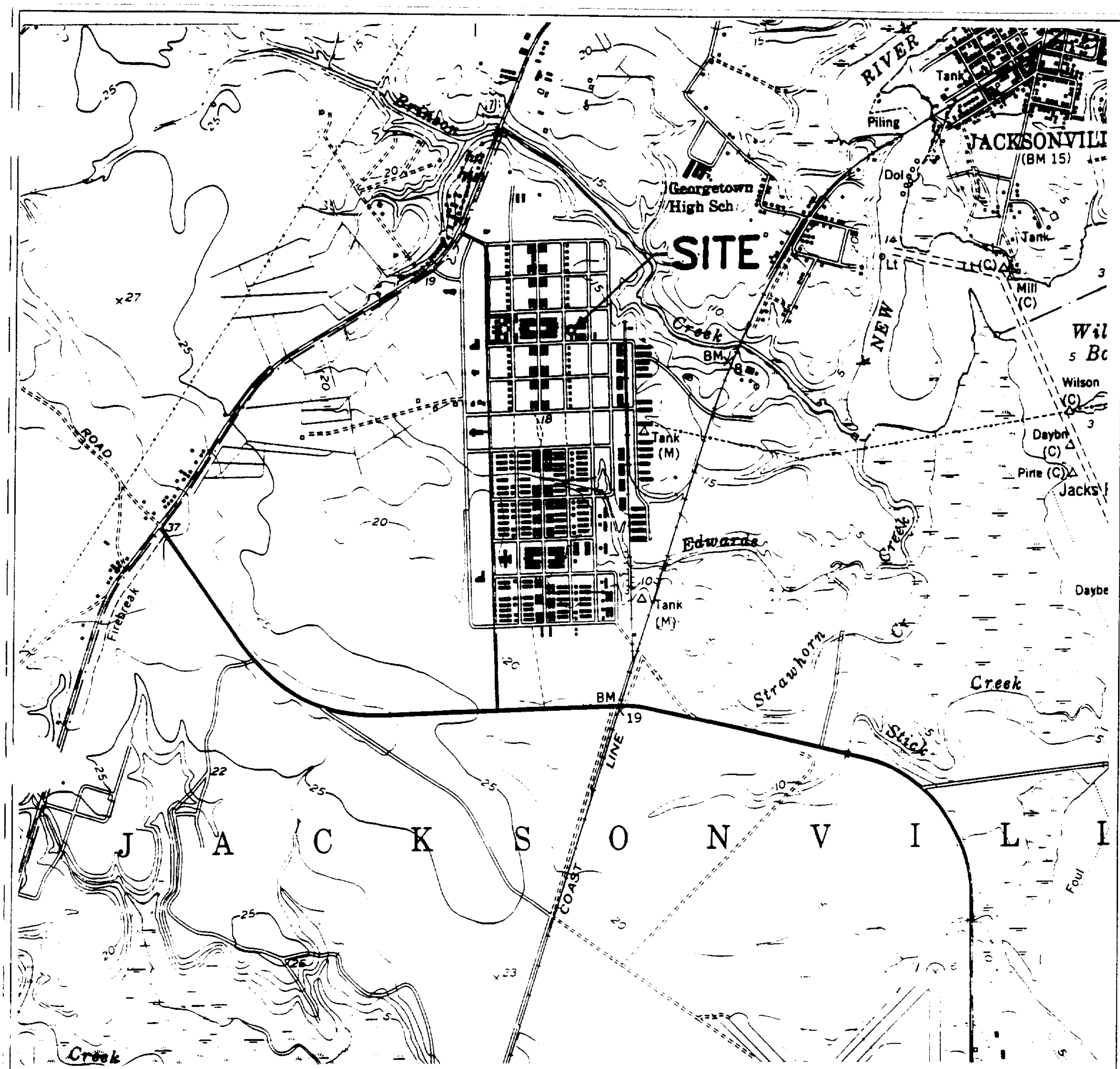
DRAWINGS



NORTH

JACKSONVILLE SOUTH, N.C.
NW/4 NEW RIVER 15' QUADRANGLE
N3437.5—W7722.5/7.5
1952
PHOTOINSPECTED 1971
AMS 5553 III NW—SERIES V842

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QUADRANGLE LOCATION

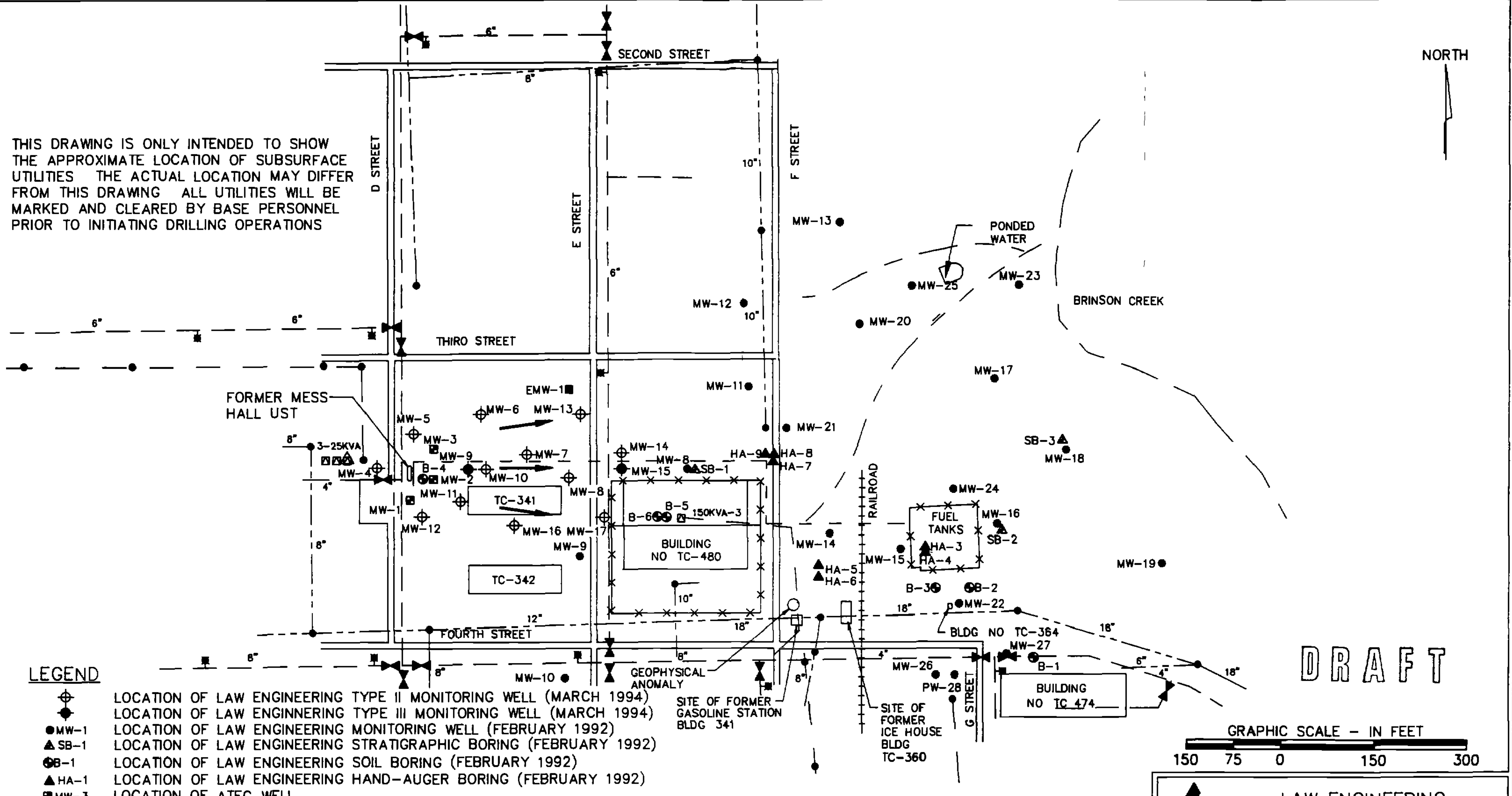
NOTE: SITE LOCATIONS ARE APPROXIMATE.

CONTOUR INTERVAL 5 FEET
GRAPHIC SCALE FEET
2000 1000 0 2000 4000

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOPOGRAPHIC SITE MAP
BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT NO. 4020

DRAWN:	DATE: APRIL 1994
DFT CHECK:	SCALE: 1:24000
ENG CHECK:	JOB: 475-09183-01
APPROVAL:	DWG: 1.1



THIS DRAWING IS ONLY INTENDED TO SHOW THE APPROXIMATE LOCATION OF SUBSURFACE UTILITIES THE ACTUAL LOCATION MAY DIFFER FROM THIS DRAWING ALL UTILITIES WILL BE MARKED AND CLEARED BY BASE PERSONNEL PRIOR TO INITIATING DRILLING OPERATIONS

LEGEND

⊕	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
●	LOCATION OF LAW ENGINNERING TYPE III MONITORING WELL (MARCH 1994)
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL (FEBRUARY 1992)
▲SB-1	LOCATION OF LAW ENGINEERING STRATIGRAPHIC BORING (FEBRUARY 1992)
⊕B-1	LOCATION OF LAW ENGINEERING SOIL BORING (FEBRUARY 1992)
▲HA-1	LOCATION OF LAW ENGINEERING HAND-AUGER BORING (FEBRUARY 1992)
▣MW-3	LOCATION OF ATEC WELL
EMW-1■	LOCATION OF PRE-EXISTING MONITORING WELL
— — —	6-INCH UNDERGROUND FUEL LINE
⟶	DIRECTION OF SHALLOW GROUNDWATER FLOW
—×—×—	FENCE
— 6" —	POTABLE WATER MAIN WITH CORRESPONDING SIZE
—⋈—	GATE VALVE
— ⊼ —	FIRE HYDRANT
— 18" —	WASTEWATER LINES WITH CORRESPONDING LINE SIZE
—•—	MANHOLE
— • —	ELECTRICAL LINES
⊠	TRANSFORMERS

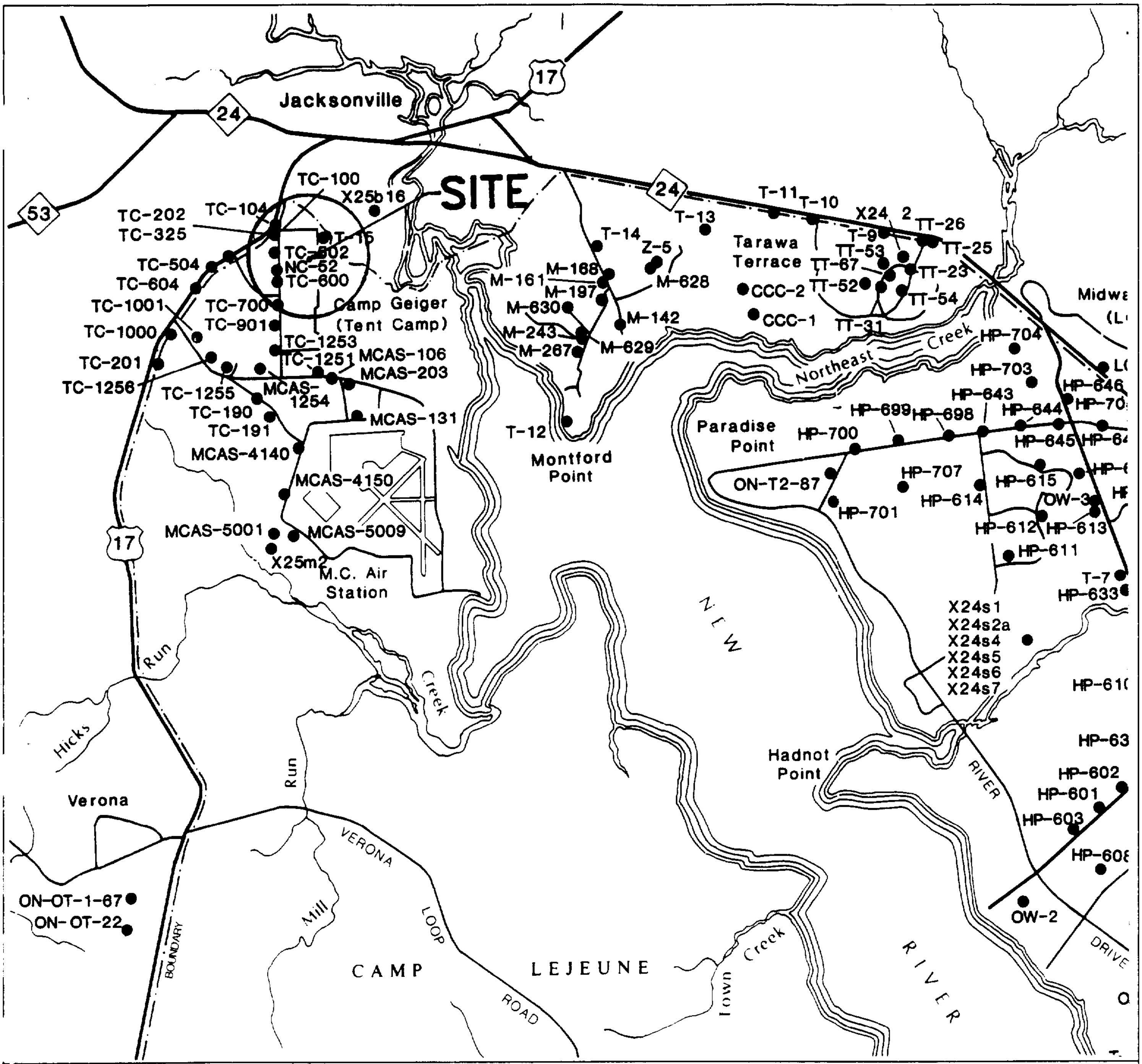
01987E012

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

CONTAMINANT SOURCE INVENTORY
HEATING PLANT BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK:	SCALE 1"=150'
ENG CHECK.	JOB 475-09183-01
APPROVAL:	DWG 2.1

REFERENCE. JAMES E STEWART AND ASSOC., SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C



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NORTH

LEGEND:

T-15	LOCATION OF WATER-SUPPLY WELL AND WELL NUMBER
○	1/2 MILE RADIUS AROUND SITE

GRAHIC SCALE – IN FEET

6560 3280 0 6560

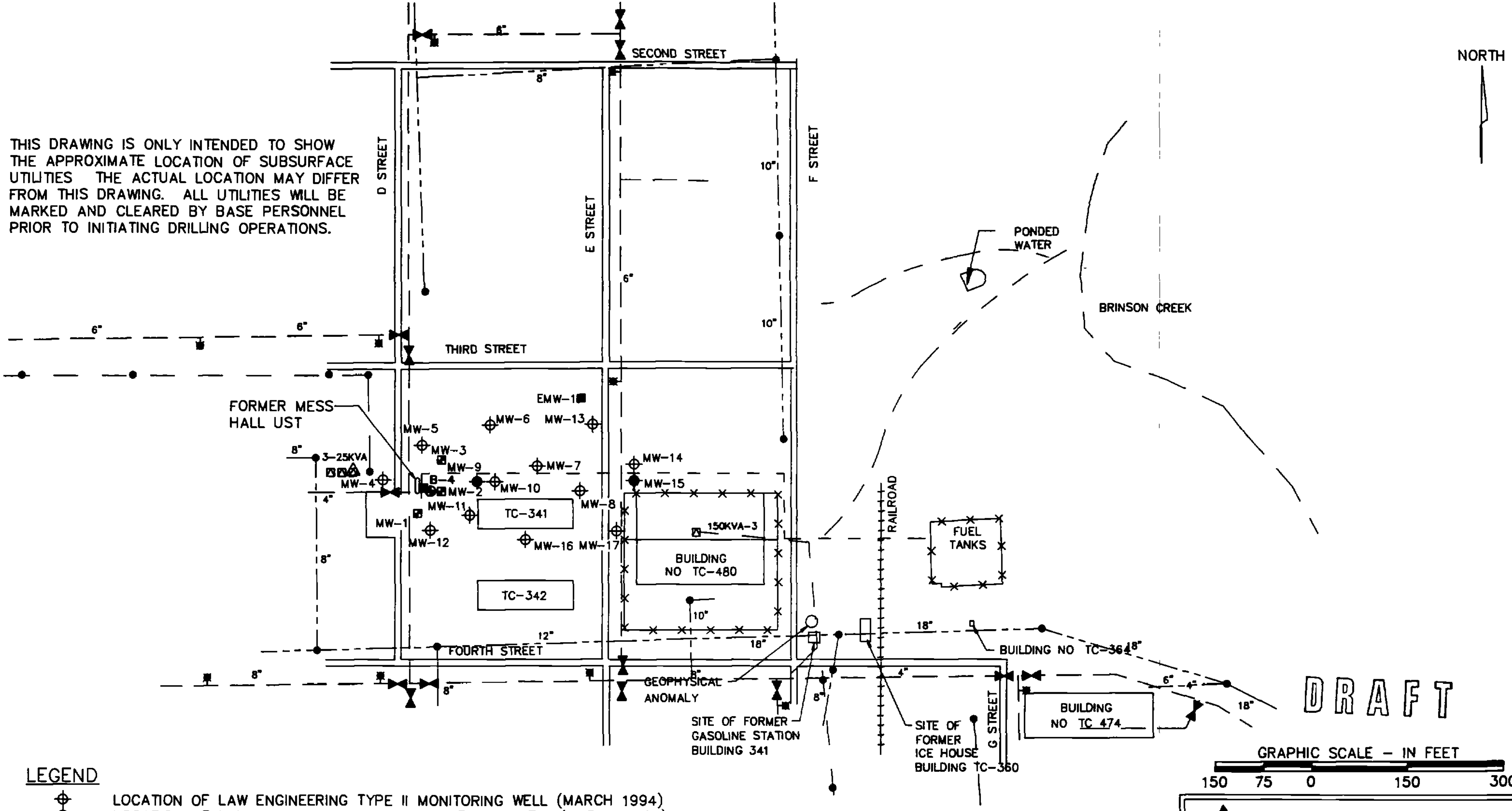
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

WATER SUPPLY WELL LOCATION MAP
BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE: APRIL 1994
DFT CHECK:	SCALE: 1"=6,560'
ENG CHECK:	JOB: 475-09183-01
APPROVAL:	DWG: 3.1

REFERENCE: DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, WATER RESOURCES REPORT 89-4096.

THIS DRAWING IS ONLY INTENDED TO SHOW THE APPROXIMATE LOCATION OF SUBSURFACE UTILITIES THE ACTUAL LOCATION MAY DIFFER FROM THIS DRAWING. ALL UTILITIES WILL BE MARKED AND CLEARED BY BASE PERSONNEL PRIOR TO INITIATING DRILLING OPERATIONS.



LEGEND

⌖	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
●	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▣MW-3	LOCATION OF ATEC WELL
EMW-1■	LOCATION OF PRE-EXISTING MONITORING WELL
— — —	6-INCH UNDERGROUND FUEL LINE
—×—×—	FENCE
— 6" —	POTABLE WATER MAIN WITH CORRESPONDING SIZE
—⋈—	GATE VALVE
— ⊥ —	FIRE HYDRANT
— 18" —	WASTEWATER LINES WITH CORRESPONDING LINE SIZE
—●—	MANHOLE
—•—	ELECTRICAL LINES
▨	TRANSFORMERS

01987E022

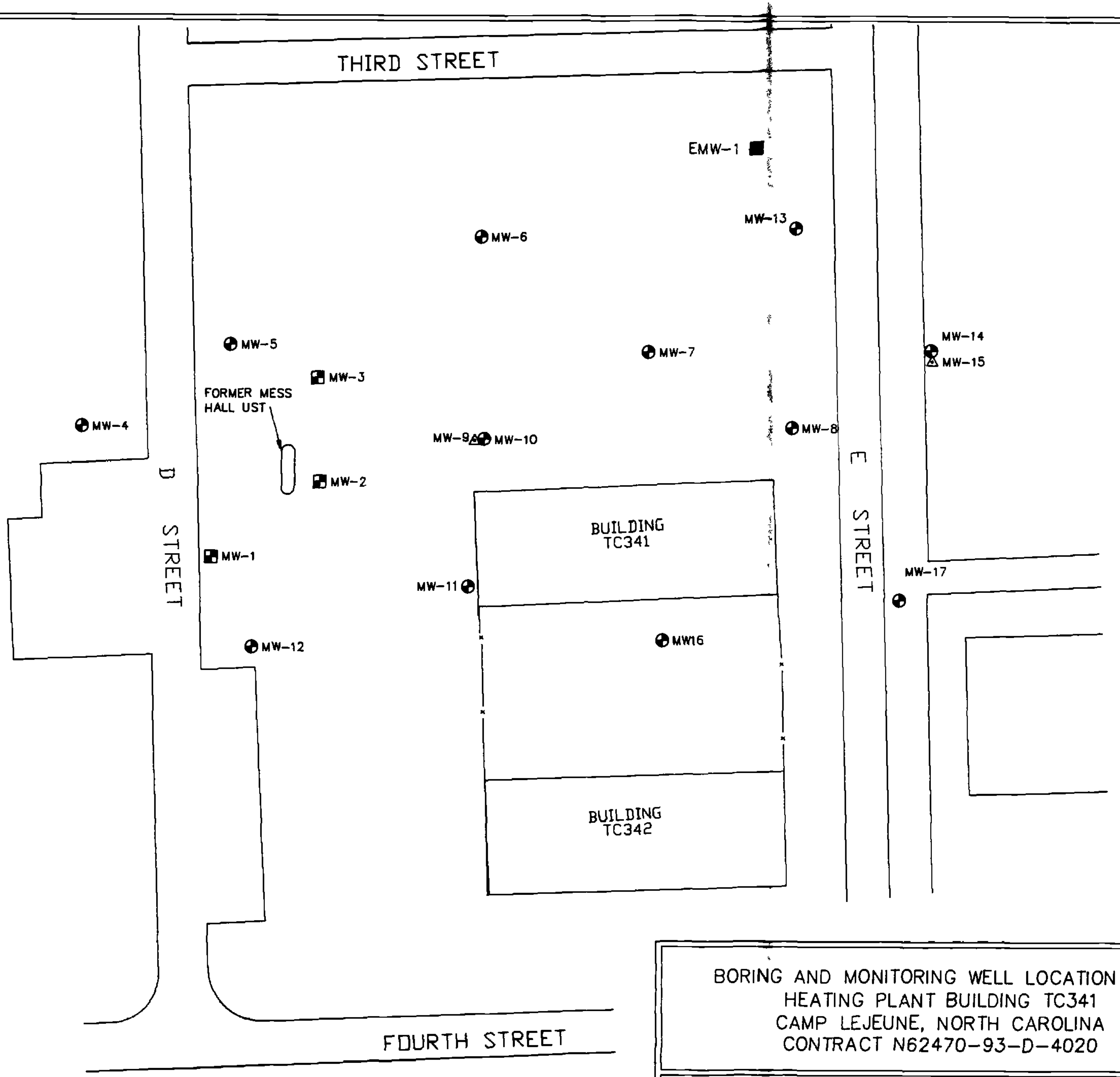
J9183J03

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

SITE UTILITIES MAP
HEATING PLANT BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: WBJ	DATE APRIL 1994
DFT CHECK.	SCALE: 1"=150'
ENG CHECK:	JOB: 475-09183-01
APPROVAL:	DWG· 3.2

REFERENCE: JAMES E STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



NOTES

1 VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19.21 FEET
2 ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3 HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4 ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5 THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

● MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL

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GRAPHIC SCALE – IN FEET

50 25 0 50 100

J0183J01

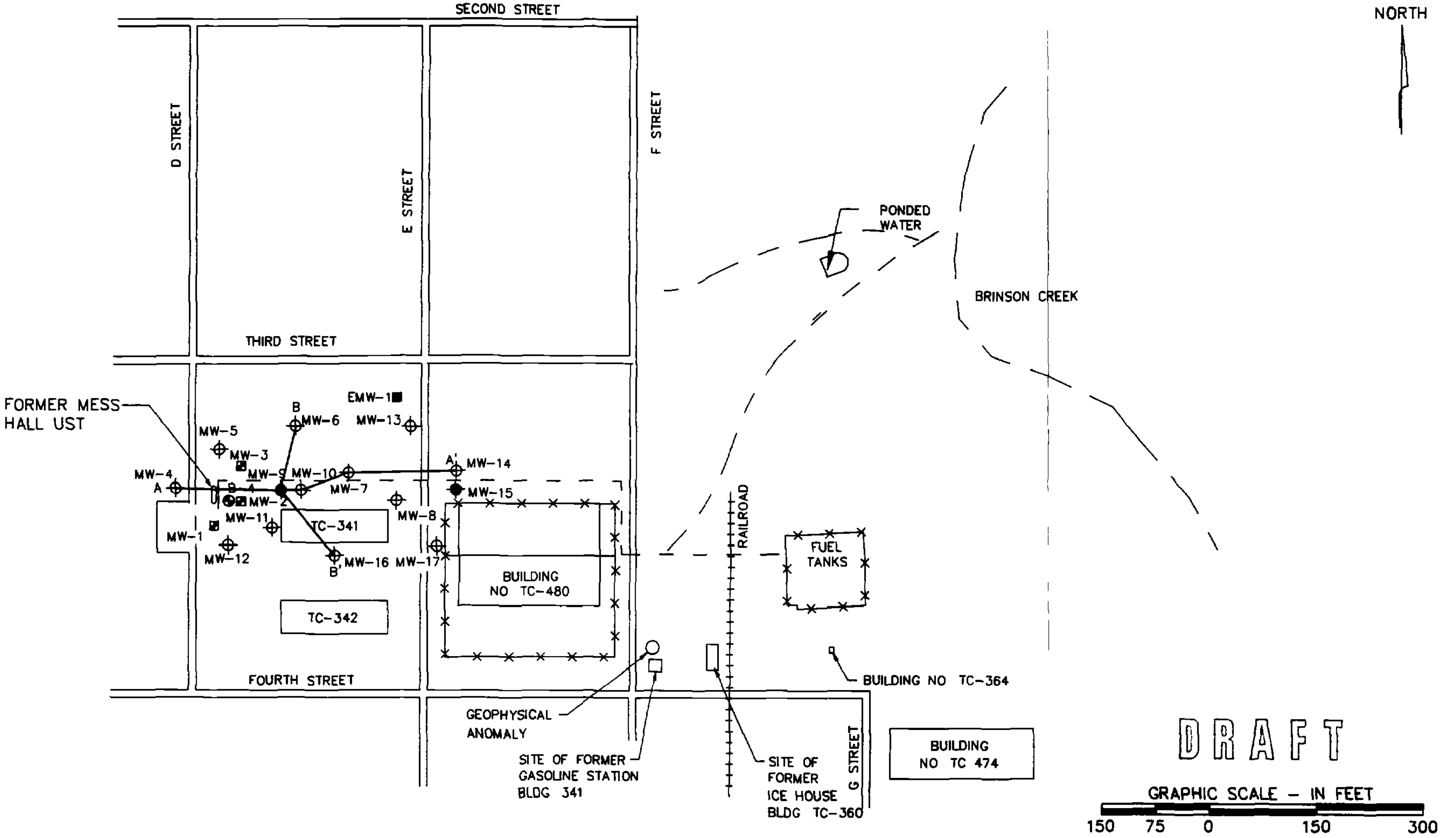
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

BORING AND MONITORING WELL LOCATION MAP
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK	SCALE. 1"=50'
ENG CHECK.	JOB 475-09183-01
APPROVAL:	DWG· 41

REFERENCE· McKIM & CREED DWG NO S.1.1.2.037

01987E032



LEGEND

⊕	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
●	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▣ MW-3	LOCATION OF ATEC WELL
EMW-1 ■	LOCATION OF PRE-EXISTING MONITORING WELL
— — —	6-INCH UNDERGROUND FUEL LINE
—×—×—	FENCE

J9183J04

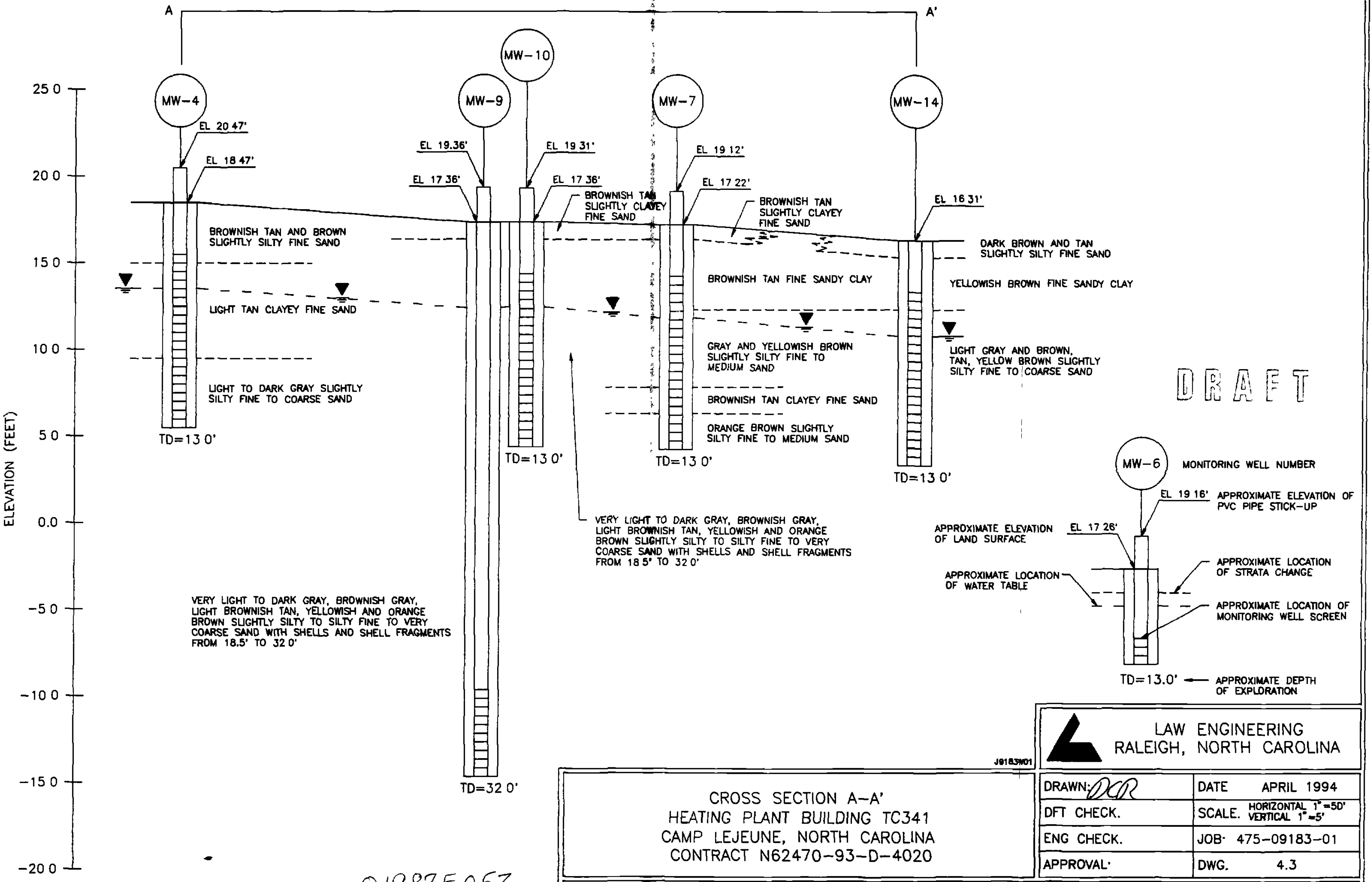
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

CROSS-SECTION PLAN VIEW
HEATING PLANT BUILDING TC-341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN. OCR	DATE. APRIL 1994
DFT CHECK.	SCALE 1"=150'
ENG CHECK.	JOB 475-09183-01
APPROVAL:	DWG. 4 2

REFERENCE. JAMES E. STEWART AND ASSOC., SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N C.

01987E04Z



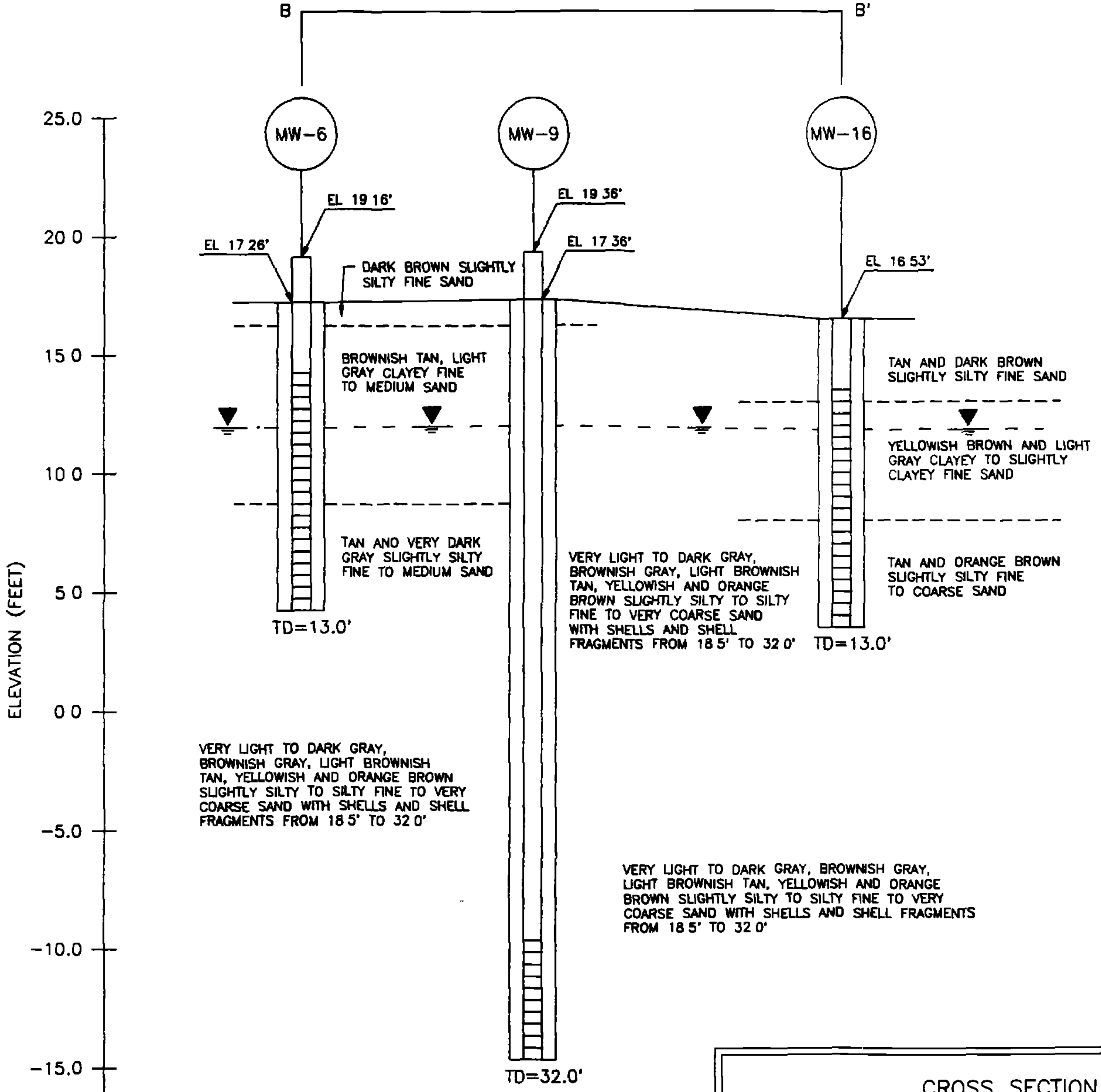
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

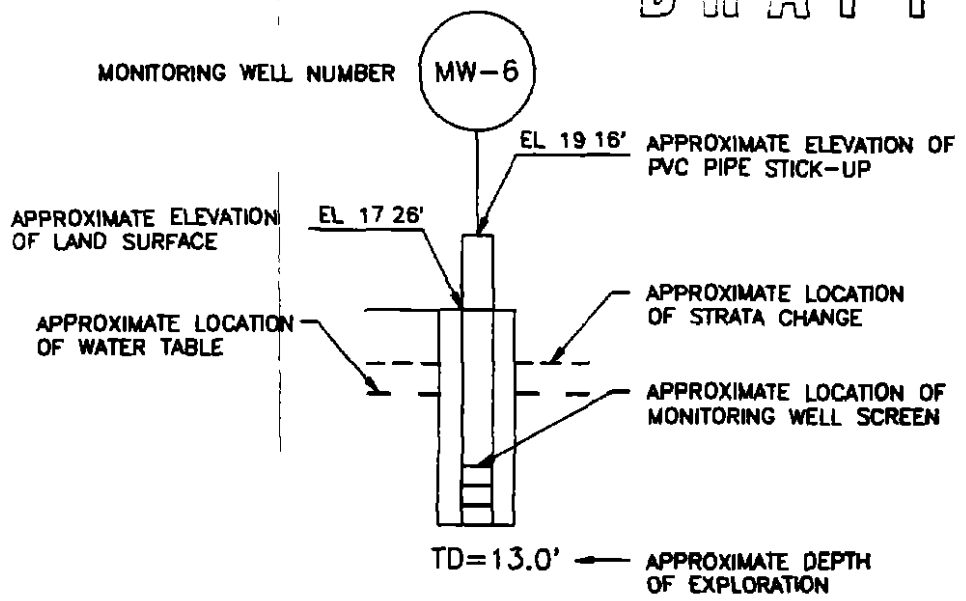
CROSS SECTION A-A'
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK.	SCALE. HORIZONTAL 1"=50' VERTICAL 1"=5'
ENG CHECK.	JOB· 475-09183-01
APPROVAL·	DWG. 4.3

REFERENCE:

01987E05Z





LAW ENGINEERING
RALEIGH, NORTH CAROLINA

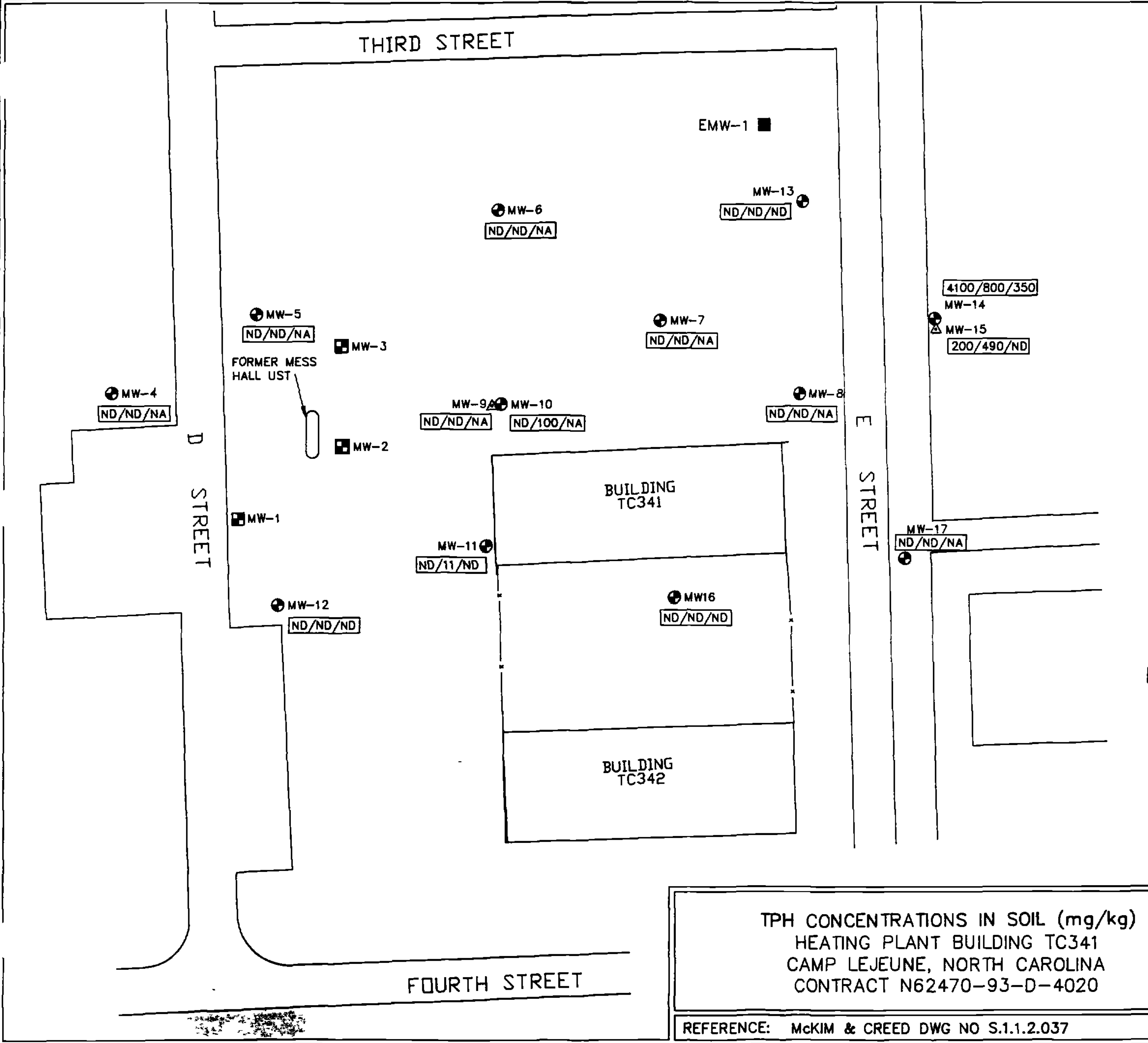
J9183W02

CROSS SECTION B-B'
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN:	DATE. APRIL 1994
DFT CHECK·	SCALE HORIZONTAL 1"=50' VERTICAL 1"=5'
ENG CHECK:	JOB: 475-09183-01
APPROVAL.	DWG: 4.4

REFERENCE:

01987E062



NORTH

NOTES

1. VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19 21 FEET
2. ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3. HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4. ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5. THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

◐ MW-4	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND/ND	NON-DETECT ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
1 0/1 0/1 0	TPH 5030 (GASOLINE)/ TPH 3550 (DIESEL) TPH OIL AND GREASE

DRAFT

GRAPHIC SCALE - IN FEET

50 25 0 50 100

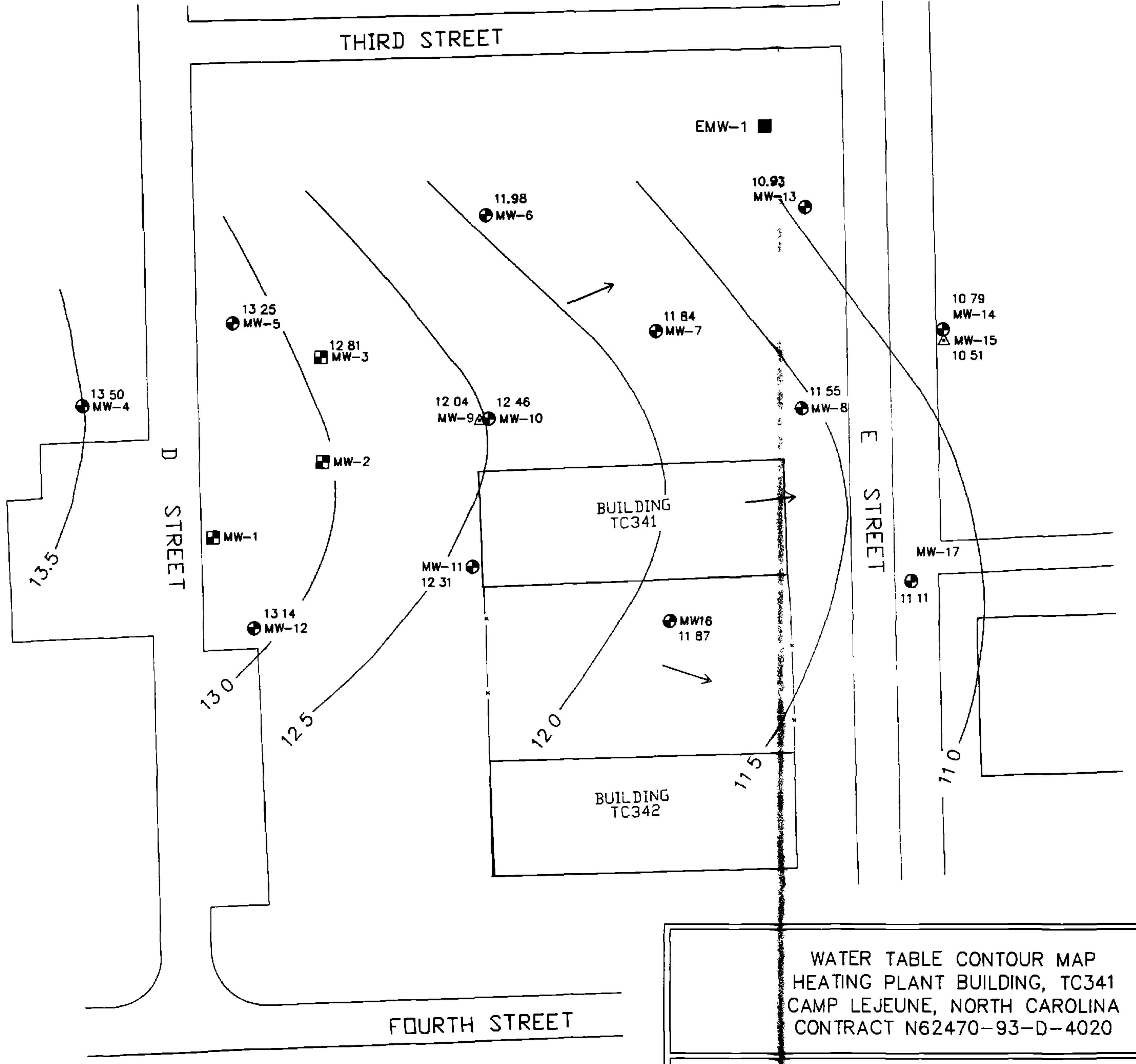
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TPH CONCENTRATIONS IN SOIL (mg/kg)
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE: APRIL 1994
DFT CHECK:	SCALE: 1"=50'
ENG CHECK:	JOB: 475-09183-01
APPROVAL:	DWG: 4.5

REFERENCE: McKIM & CREED DWG NO S.1.1.2.037

01987E072



NORTH

NOTES

1. VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19 21 FEET
2. ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3. HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE".
4. ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED.
5. THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

DRAFT

LEGEND

● MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▨ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
←	DIRECTION OF SHALLOW GROUNDWATER FLOW
— x — x	CHAIN LINK FENCE
——	WATER TABLE ELEVATION CONTOUR (3-30-94)

NOTE. NUMBERS BESIDE WELLS ARE GROUND-WATER ELEVATIONS MEASURED ON 3/30/94 FREE PRODUCT WAS DETECTED IN WELLS MW-2 AND MW-1 THEREFORE WATER TABLE ELEVATIONS ARE NOT SHOWN FOR THESE WELLS

GRAPHIC SCALE – IN FEET

50 25 0 50 100

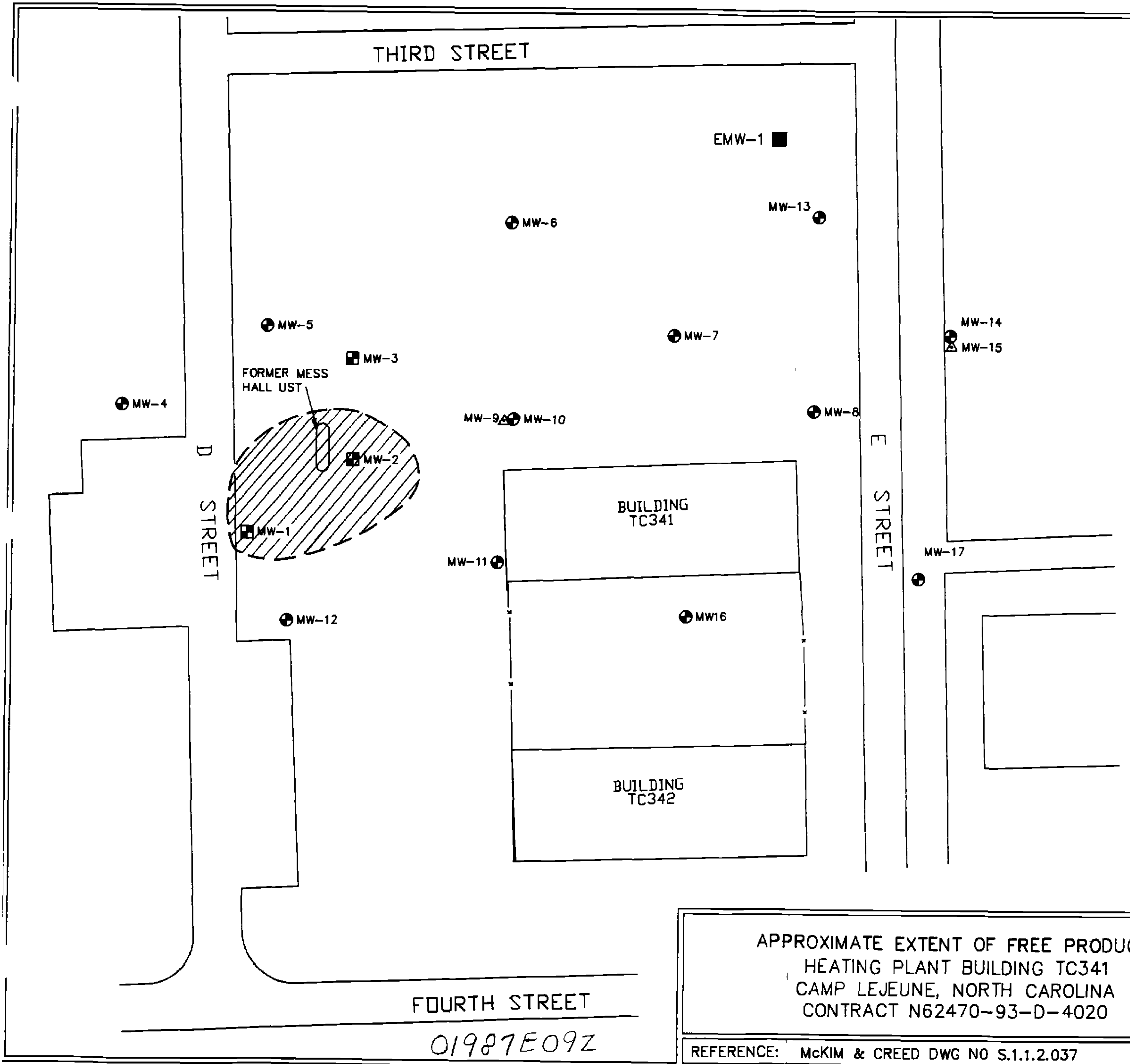
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

WATER TABLE CONTOUR MAP
HEATING PLANT BUILDING, TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN DCR	DATE. APRIL 1994
DFT CHECK	SCALE 1"=50'
ENG CHECK.	JOB 475-09183-01
APPROVAL:	DWG. 5.1

REFERENCE: McKIM & CREED DWG NO S.1.1.2.037

01987E08Z



01987E092

NORTH

NOTES

1. VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19 21 FEET
2. ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3. HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4. ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5. THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

⊕ MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▣ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
— — —	ESTIMATED FREE PRODUCT EXTENT CONTOUR

GRAPHIC SCALE – IN FEET

50 25 0 50 100

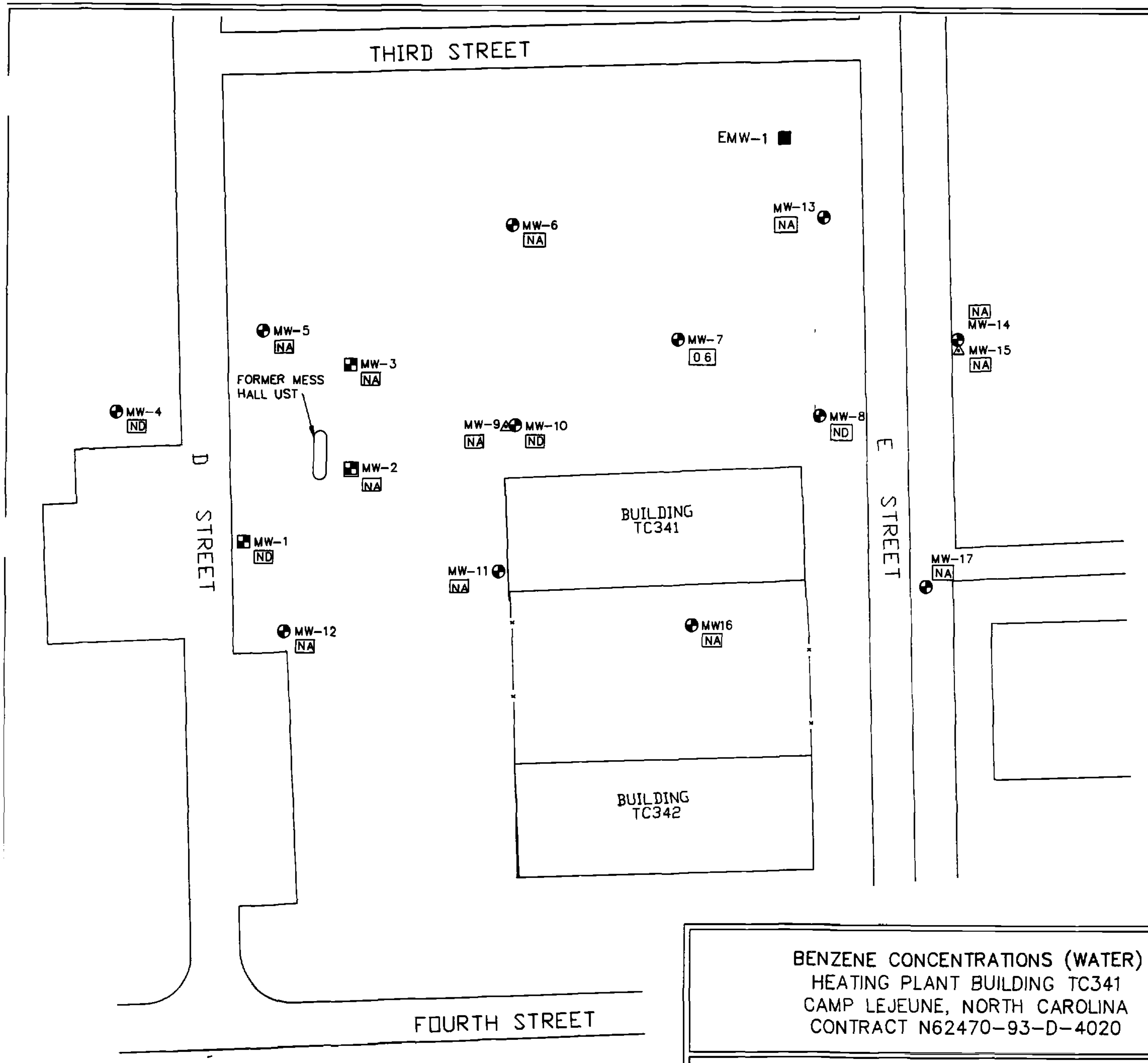
J9183J09

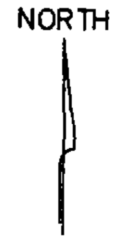
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

APPROXIMATE EXTENT OF FREE PRODUCT
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK:	SCALE: 1"=50'
ENG CHECK	JOB 475-09183-01
APPROVAL	DWG 5.2

REFERENCE: McKIM & CREED DWG NO S.1.1.2.037





NOTES

1 VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19 21 FEET
2 ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3 HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4 ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5 THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

● MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▨ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND	NON-DETECT ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
0 6	CONCENTRATION OF TOTAL BENZENE (ug/L)

NOTE.
15A NCAC 2L STANDARD FOR BENZENE EQUALS 1 ug/L

GRAPHIC SCALE - IN FEET
50 25 0 50 100

J9183J07

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

BENZENE CONCENTRATIONS (WATER)
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK	SCALE 1"=50'
ENG CHECK.	JOB. 475-09183-01
APPROVAL·	DWG 5.3

REFERENCE· McKIM & CREED DWG NO S.1.1.2.037

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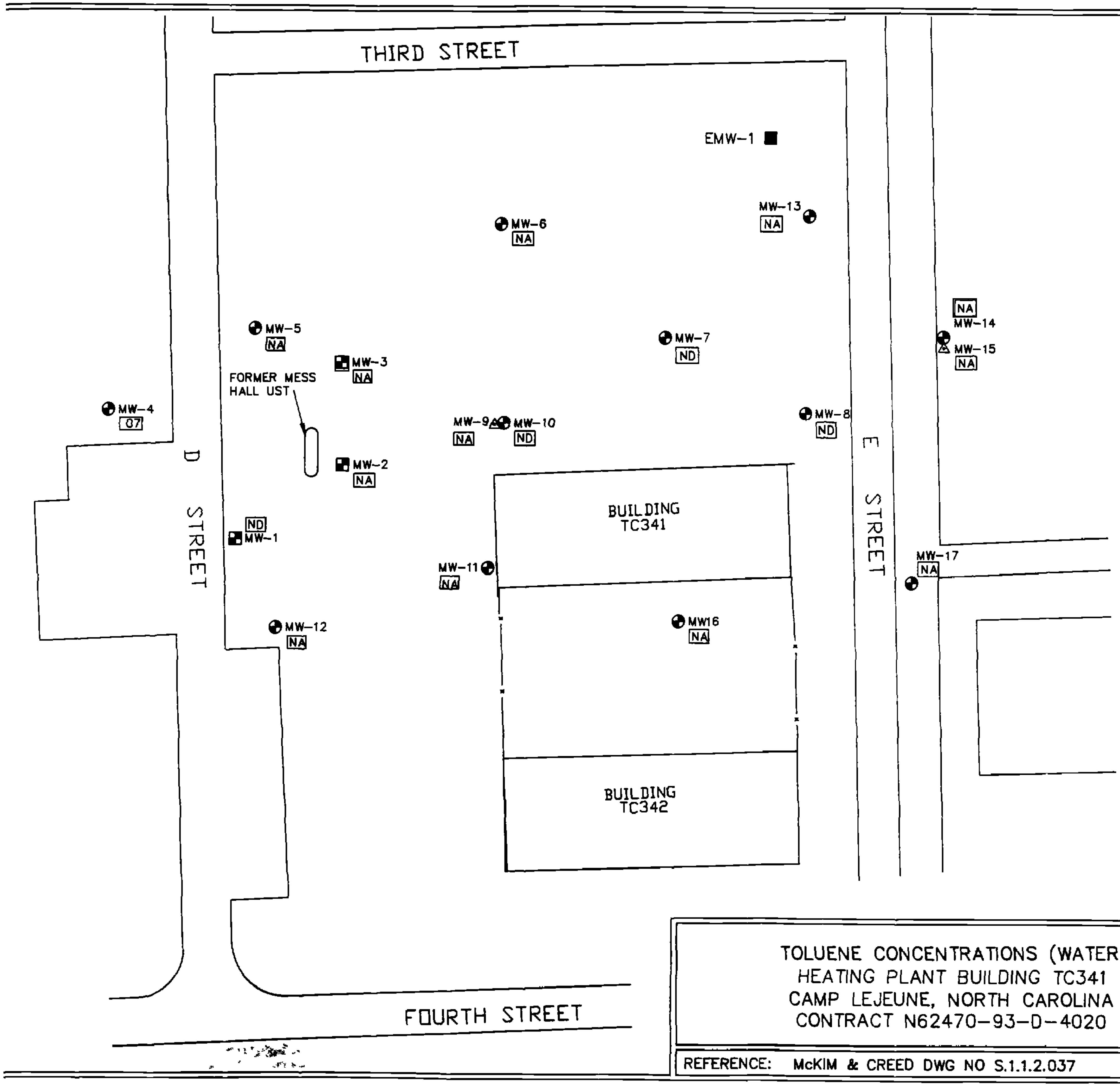

NORTH

NOTES.

1 VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19.21 FEET
2 ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3 HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4 ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5 THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

DRAFT

● MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND	NON-DETECT ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
14 6	CONCENTRATION OF TOTAL TOLUENE (ug/L)

NOTE.
15A NCAC 2L STANDARD FOR TOLUENE EQUALS 1,000 ug/L

GRAPHIC SCALE – IN FEET
50 25 0 50 100

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

J9183J10

TOLUENE CONCENTRATIONS (WATER)
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK.	SCALE. 1"=50'
ENG CHECK.	JOB: 475-09183-01
APPROVAL.	DWG· 5.4

REFERENCE: McKIM & CREED DWG NO S.1.1.2.037

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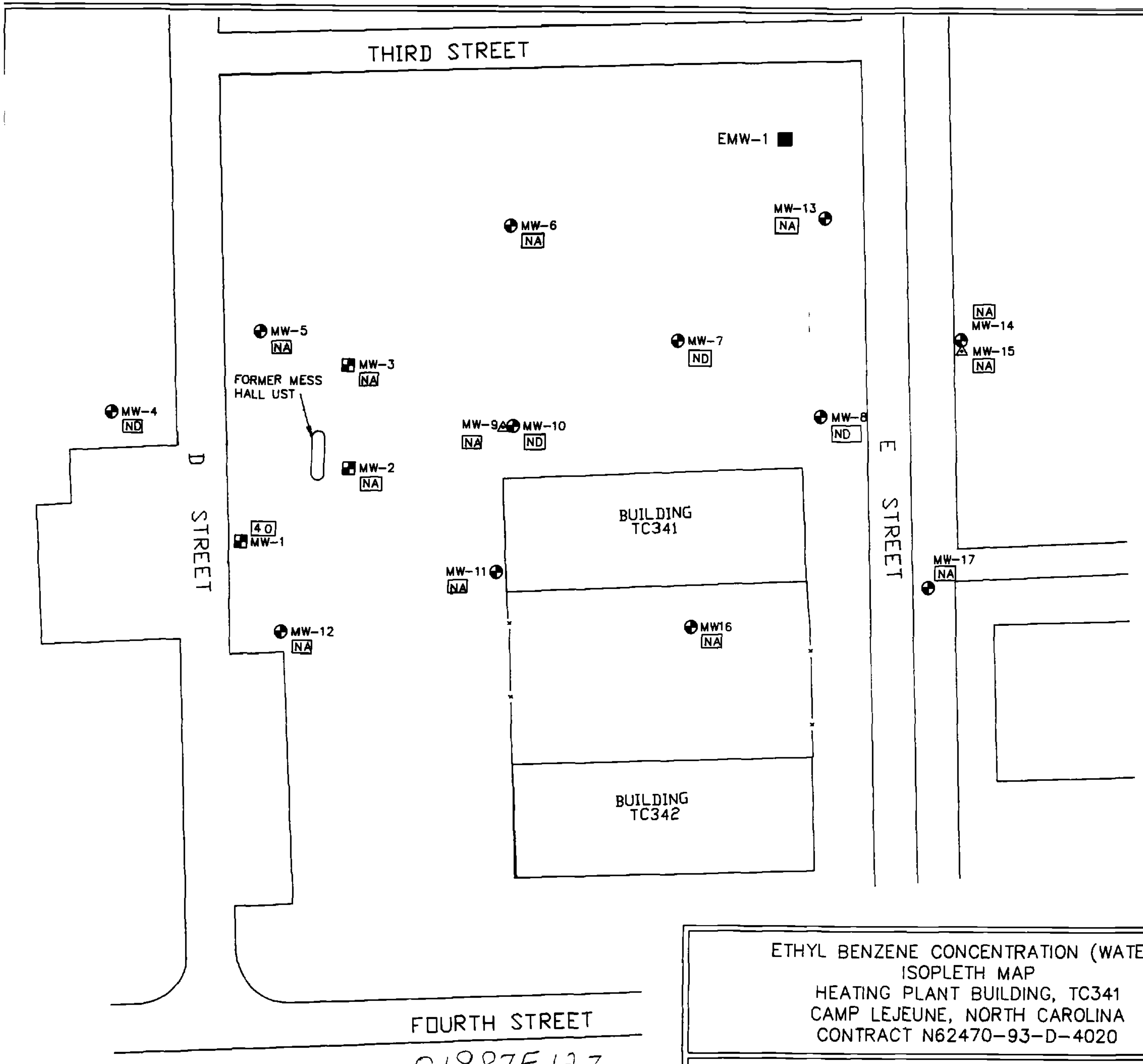

NORTH

NOTES

1. VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT STAFF WITH AN GIVEN ELEVATION OF 19 21 FEET
2. ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3. HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE"
4. ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD.DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5. THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY

LEGEND

⊕ MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION PRE-EXISTING MONITORING WELL
ND	NON-DETECT ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
14 6	CONCENTRATION OF TOTAL ETHYL BENZENE (ug/L)

NOTE
15A NCAC 2L STANDARD FOR ETHYL BENZENE
EQUALS 29 ug/L

GRAPHIC SCALE – IN FEET
50 25 0 50 100

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

J9183JR1

ETHYL BENZENE CONCENTRATION (WATER)
ISOPLETH MAP
HEATING PLANT BUILDING, TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN DCR	DATE: APRIL 1994
DFT CHECK	SCALE 1"=50'
ENG CHECK.	JOB 475-09183-01
APPROVAL:	DWG 5 5

REFERENCE: McKIM & CREED DWG NO S 1 1.2.037

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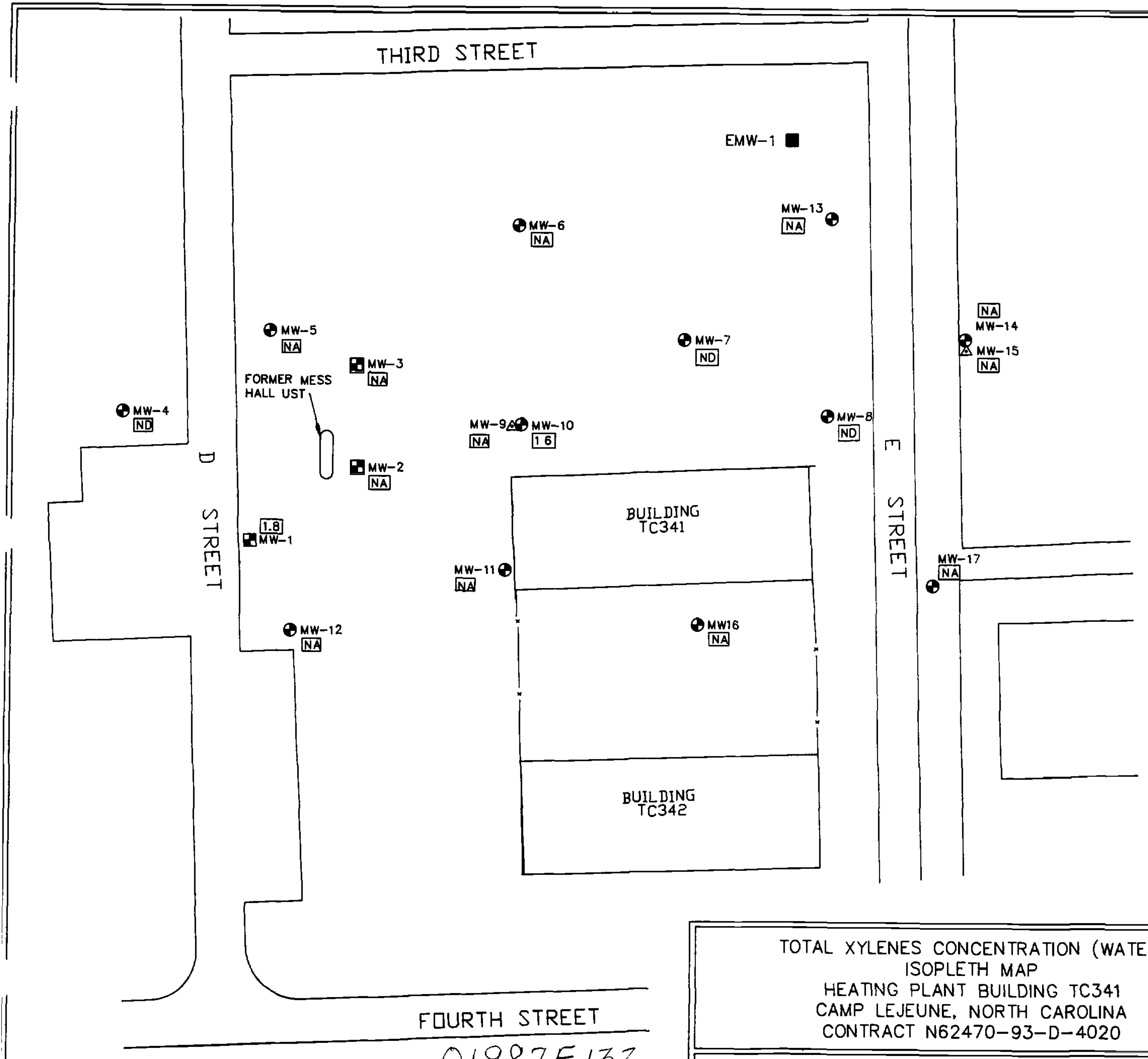

NORTH

NOTES

1 VERTICAL DATUM IS BASED ON EXISTING NCGS MONUMENT "STAFF" WITH AN GIVEN ELEVATION OF 19.21 FEET
2 ALL ELEVATIONS ON MONITORING WELLS WERE TAKEN AT THE TOP OF THE PVC CASING
3 HORIZONTAL DATUM BASED ON NCGS MONUMENTS "STAFF" AND "WASHETTE".
4 ALL LOCATIONS OF BUILDING, STREETS, AND PARKING AREA WERE TAKEN FROM A CAMP LEJEUNE BASE MAP AUTOCAD DWG FILE SUPPLIED BY LAW ENGINEERING UNLESS OTHERWISE NOTED
5 THE MONITORING WELLS, AND THE CORNERS OF BUILDING TC 341 AND TC 342 WERE THE ONLY POINTS LOCATED IN THE FIELD BY THIS SURVEY ALL OTHER LOCATIONS WERE TAKEN FROM THE ABOVE REFERENCED FILE, AND MAY OR MAY NOT BE SHOWN CORRECTLY.

DRAFT

LEGEND

◒ MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND	NON-DETECT ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
14.6	CONCENTRATION OF TOTAL XYLENES (ug/L)

NOTE.
15A NCAC 2L STANDARD FOR TOTAL XYLENES EQUALS 530 ug/L

GRAPHIC SCALE – IN FEET
50 25 0 50 100

J9183J12

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOTAL XYLENES CONCENTRATION (WATER)
ISOPLETH MAP
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN. DCR	DATE: APRIL 1994
DFT CHECK	SCALE. 1"=50'
ENG CHECK.	JOB: 475-09183-01
APPROVAL	DWG. 5.6

REFERENCE: McKIM & CREED DWG NO S.1.1.2.037

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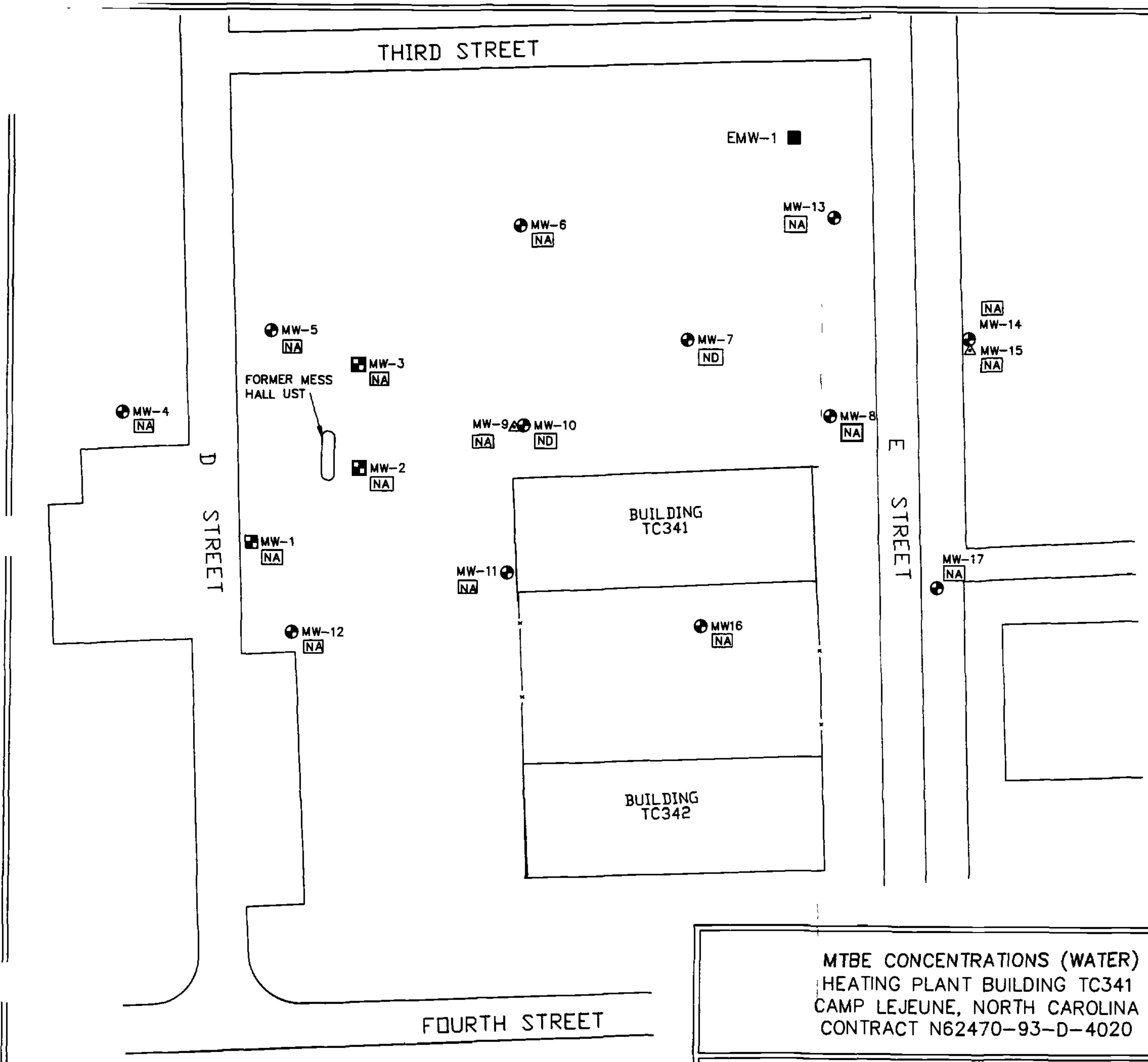

NORTH

NOTES

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DRAFT

LEGEND

◕ MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▚ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND	NON-DETECTED ABOVE LABORATORY QUANTITATION LIMITS
NA	NOT ANALYZED DURING LAW ENGINEERING COMPREHENSIVE SITE ASSESSMENT
14 6	CONCENTRATION OF TOTAL MBTE (ug/L)

NOTE:
15A NCAC 2L STANDARD FOR MTBE EQUALS 200 ug/L

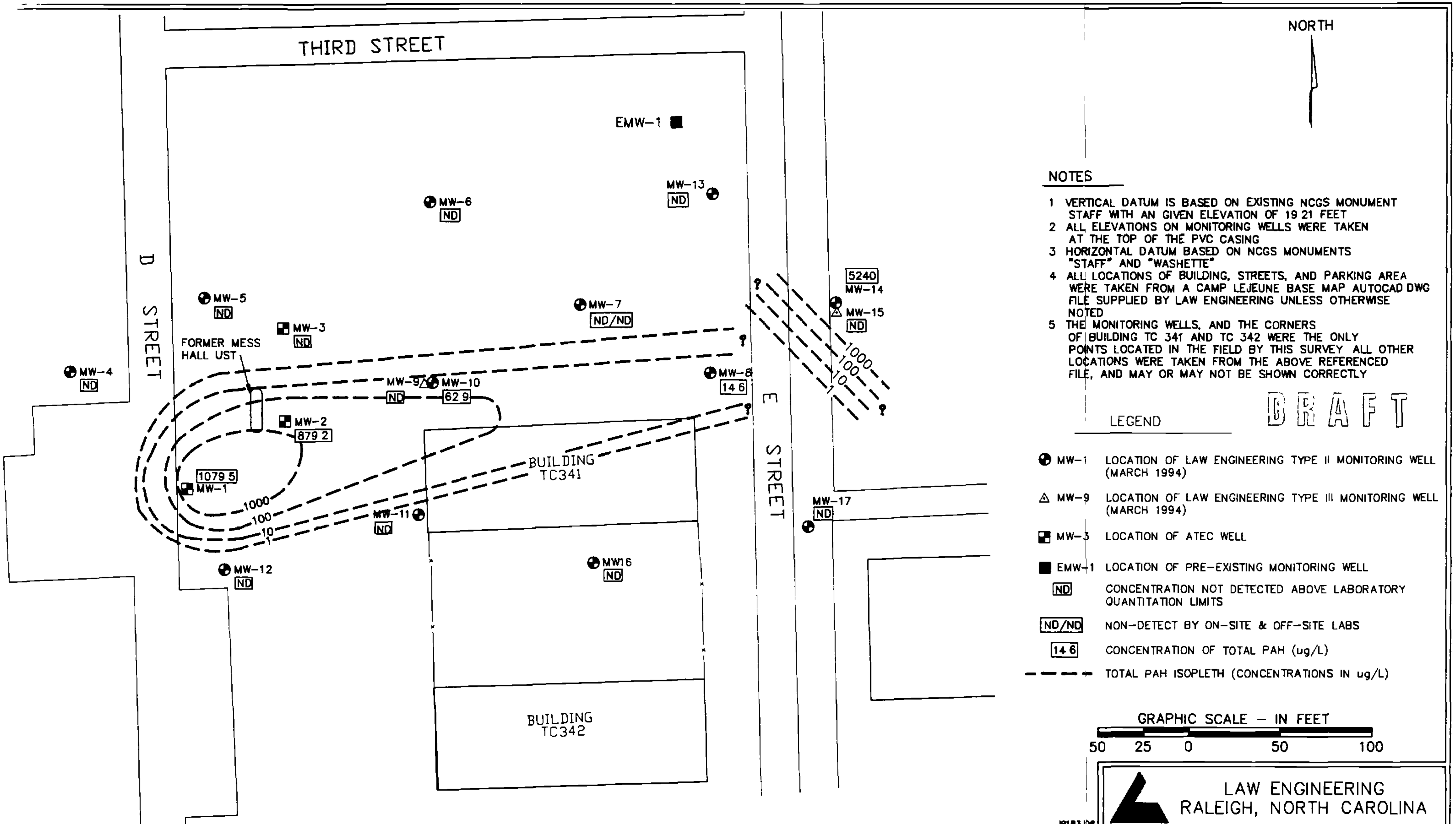
GRAPHIC SCALE – IN FEET
50 25 0 50 100

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

MTBE CONCENTRATIONS (WATER)
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN. DCR	DATE APRIL 1994
DFT CHECK.	SCALE. 1"=50'
ENG CHECK.	JOB· 475-09183-01
APPROVAL:	DWG: 5 7

REFERENCE· McKIM & CREED DWG NO S.1.1 2.037



NOTES

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LEGEND

● MW-1	LOCATION OF LAW ENGINEERING TYPE II MONITORING WELL (MARCH 1994)
△ MW-9	LOCATION OF LAW ENGINEERING TYPE III MONITORING WELL (MARCH 1994)
▨ MW-3	LOCATION OF ATEC WELL
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
ND	CONCENTRATION NOT DETECTED ABOVE LABORATORY QUANTITATION LIMITS
ND/ND	NON-DETECT BY ON-SITE & OFF-SITE LABS
14 6	CONCENTRATION OF TOTAL PAH (ug/L)
— — —	TOTAL PAH ISOPLETH (CONCENTRATIONS IN ug/L)

GRAPHIC SCALE – IN FEET
50 25 0 50 100

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOTAL PAH CONCENTRATIONS (WATER) – ISOPLETH MAP
HEATING PLANT BUILDING TC341
CAMP LEJEUNE, NORTH CAROLINA
CONTRACT N62470-93-D-4020

DRAWN: DCR	DATE APRIL 1994
DFT CHECK	SCALE. 1"=50'
ENG CHECK.	JOB: 475-09183-01
APPROVAL:	DWG. 5.8

REFERENCE: McKIM & CREED DWG NO S 1.1.2.037

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