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FINAL UNDERGROUND FUEL INVESTIGATION COMPREHENSIVE SITE ASSESSMENT
REPORT VOLUME 1 TANK FARM A MCAS CHERRY POINT NC
4/12/1991
LAW ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

**FINAL REPORT
UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT**

VOLUME I

**TANK FARM A
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA**

April 12, 1991

Law Engineering Job No. J47590-6013A

Law Engineering, Inc.
Raleigh, North Carolina





LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL
& CONSTRUCTION MATERIALS
CONSULTANTS

April 12, 1991

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

Attention: Code 1821, Mr. Trueman Seamans
Engineer-In-Charge

Subject: FINAL REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
TANK FARM A
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6013A

Dear Mr. Seamans:

In accordance with Naval Facilities Engineering Command Order for Supplies and Services Contract No. N62470-90-D-7625/0001 dated September 29, 1990, Law Engineering 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 Comprehensive Site Assessment Report, included performance of soil test borings and collection of soil samples for chemical testing; installation of ground-water monitoring wells and collection of ground-water samples for chemical testing; and investigation of the geology and hydrogeology in the area of Tank Farm A. The objective of our services was to provide an assessment of the extent/severity of and possible exposure to subsurface petroleum contamination caused by leaks from the underground fuel storage tank system.

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. The findings are relevant to the dates of our site work and should not be relied upon to represent site conditions on other dates.

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P.O. BOX 18288
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919-876-0416



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

Sincerely,

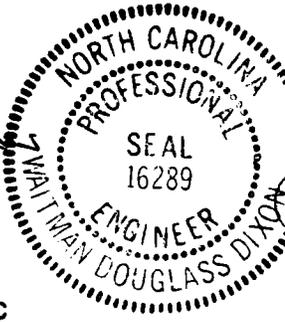
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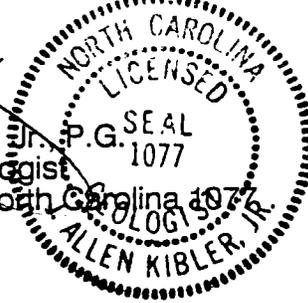
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1.0 INTRODUCTION

1.1 Purpose of Investigation

On September 29, 1990, the Commander of the Atlantic Division Naval Facilities Engineering Command in Norfolk, Virginia, contracted with Law Companies Group, Inc. to perform a Comprehensive Site Assessment (CSA) at the Tank Farm A facility at Cherry Point Marine Corps Air Station (MCAS), Cherry Point, 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 petroleum fuels. ~~As stated in the CSA 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 ^{of the} Criteria and Standards Applicable to Underground Storage Tanks. ^{and}

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/Purchase Order No. N62470-90-D-7625/0001 dated September 29, 1990.



As outlined in the contract and the CSA Workplan, the Scope of Work included preparation of a health and safety plan, excavation of soil borings, installation of monitoring wells, collection and analysis of soil and ground-water samples, performance of a preliminary exposure assessment, performance of a preliminary evaluation of remedial alternatives, preparation of a final report of investigation and presentation of data and conclusions. Specific methods employed during performance of the project activities are described within the appropriate sections of this Report.

2nd phase

1.3 Previous Investigation

An initial investigation, which began in 1984, was conducted at Tank Farm A by NUS Corporation. According to the NUS report (NUS, 1988), fifteen soil test borings were advanced and eight ground-water monitoring wells were installed at Tank Farm A to determine the extent of petroleum fuel contamination at the site. Local ground-water flow direction was determined from water levels in the eight wells and estimated to be directed towards the northeast. A Petro-Tite tank tightness test was performed on tank nos. 1106, 1107, 1108 and 1109. NUS reported the four tanks tested to be "fairly tight".

Results of laboratory tests performed by NUS revealed that ground water in the vicinity of Tank Farm A is contaminated with petroleum fuel related hydrocarbons. At the time of ground-water sampling, 3 to 6 feet of free phase petroleum hydrocarbons (free product) were present in five of the eight monitoring wells. JP-4 and JP-5 type fuel was verified by gas chromatography to be present in ground-water samples collected.



In addition to the NUS assessment, several hydrogeologic investigations have been performed at Cherry Point MCAS. These investigations are summarized in U.S. Geological Survey (USGS) Water-Resources Investigations Reports 88-4034 (Lloyd, 1988), and 89-4200 (Murray, 1990b) and USGS Open-File Report 89-615 (Murray, 1990a). These studies are referenced fully in Section 8.0 of this Report. USGS reports include discussions of hydrogeology and quality of ground water from existing drinking water wells and ground-water monitoring wells located at Cherry Point MCAS.

2.0 SITE DESCRIPTION

2.1 Area of Investigation

The project site is located along Sixth Avenue, south of Building 250 and Building 1016 at Cherry Point MCAS, Cherry Point, Carteret County, North Carolina (Drawing 1.1). The site is situated entirely within the confines of the MCAS and is bounded to the north and east by the base runway; and to the south and west by base operational facilities.

2.2 Site History and Operations

Approximately 4 acres in size, Tank Farm A stores JP-5 (jet fuel), diesel, and gasoline in numerous tanks located throughout the farm. According to Mr. R. M. Hawthorne of Cherry Point MCAS Fuel Department, the initial tanks were placed in service in early 1940's and many of the original tanks are still in operation. Fuel tank nos. 1191, 1192, 1194, 4001, 4002, receive fuel via underground pipelines from Tank Farm B located



approximately 4000 feet northeast of Tank Farm A. These tanks range in size from 105,000 gallon capacity to 410,000 gallon capacity. All other tanks receive fuel via trucks operated by commercial carrier.

Several of the original tanks have been removed or replaced since the 1940's. Tank no. 1246 was removed 3-4 years ago. Another tank (which had no assigned number) was removed and replaced in 1990 (to be numbered). Tank nos. 1110, 1111, 1112, and 1113 were installed in 1943 and removed in 1982.

The Department of the Navy warranted the first phase of an Installation Restoration (IR) program, and summarized the results in an Initial Assessment Study (IAS), dated March 1983. Conducted by the U.S. Environmental Protection Agency, results of the IAS showed that sufficient evidence existed to indicate the potential presence of contaminants which might pose a health or environmental threat on or off the facility.

2.3 Contaminant Source Inventory

Underground and aboveground storage tanks identified at Tank Farm A are listed in Table 2.1 along with the product type, installation date, size of tank, tank status and comments. The location of the underground tanks with respect to the site are presented in Drawing 2.1. It should be noted that Table 2.1 includes only those tanks that have been identified during the course of this investigation. The possibility remains, however, that other unidentified underground storage tanks are present near Tank Farm A or were located at Tank Farm A in the past.



In addition to the underground storage tanks located at Tank Farm A and listed in Table 2.1, numerous active and inactive product transmission lines are or have been located at Tank Farm A. These product lines are presented in Drawing 2.1.

2.4 Water Well Inventory

In order to identify potential receptors of ground-water contaminants, a survey of drinking water wells in the vicinity of Tank Farm A was performed by reviewing USGS Reports 88-4034, 89-615 and 89-4200 and by reviewing well geophysical logs provided by Ms. Renee' Henderson of Cherry Point Natural Resources and Environmental Affairs Department (NREA). The well survey area and locations of drinking water wells identified by the survey are shown in Drawing 2.2. Information on ground water use was obtained from USGS reports and from conversations with NREA. A discussion of the results of the potential receptors survey is provided in Section 6.0 of this Report.

Based on water levels measured in Cherry Point MCAS water supply wells during December 1988 by USGS and depicted in potentiometric surface cross sections presented in USGS Report 89-4200 (Murray, 1990b), the radius of influence for active water wells appears to be approximately 500 to 800 feet. Therefore, the well survey targeted wells located within one-half mile of the project site in order to provide for adequate coverage area.

A summary of inventory results is presented in Table 2.2. Information is provided on the well depth, casing diameter, well usage and the well's approximate distance from Tank Farm A. Each of the wells identified were constructed as open hole wells in the Castle



Hayne Aquifer. The Castle Hayne Aquifer and the hydrogeology of the area are introduced and referenced in Section 3.2 of this report.

2.5 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 Tank Farm A. Data on the location of utilities was provided by Cherry Point MCAS Naval Facilities Engineering in the form of plans and drawings. Based on the information provided, it appears that numerous subsurface utilities are buried in the vicinity of Tank Farm A. The locations of these utilities with respect to Tank Farm A are shown in Drawings 2.3 through 2.6. Typically, underground utility lines are buried 2 to 6 feet below land surface (BLS). As previously indicated, underground fuel transmission lines are exhibited in Drawing 2.1.

3.0 **RESULTS OF INVESTIGATION**

3.1 Site Topography

As indicated by the 1949 (photorevised 1983) Havelock, North Carolina USGS Topographic Quadrangle and Drawing 3.1, the land surface elevations in the vicinity of Tank Farm A generally range from 21 to 25 feet above mean sea level (msl) and the land surface slopes gradually toward the north. Since topographic relief is very slight and much of the area surrounding Tank Farm A is paved, most of the runoff is channeled to



underground storm sewer facilities (Drawing 2.5). However, some runoff exits the site via drainage ditch along Sixth Avenue (Drawing 3.1).

3.2 Regional Geology/Hydrogeology

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. A brief summary of the geologic/hydrogeologic setting at Cherry Point MCAS is provided in Section 2.1 of 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 several published reports of investigations conducted by USGS. As previously indicated, these studies are referenced in Section 8.0 of this Report.

3.3 Site Soils and Geology

Drilling, soil sampling and monitoring well installation activities were initiated on October 9, 1990 and completed on October 30, 1990. Initial assessment of the geology and soil contamination at Tank Farm A was accomplished by drilling ten soil test borings at the locations indicated in Drawing 3.2. Seventeen additional borings were subsequently drilled in order to further characterize site geology, assess the extent of possible soil contamination and provide for installation of ground-water monitoring wells. Locations of these borings/wells are also shown in Drawing 3.2. All drilling was



accomplished using the hollow stem auger (HSA) technique (ASTM D-1452) with the exception of drilling required to install the inner casing of 13GW11 which utilized the wash rotary drilling technique. Augers of 6.25-inch I.D. were used to advance the boreholes. Soil borings not intended for monitoring well installation were filled with grout to land surface. All down-hole drilling equipment was steam cleaned prior to work at each drilling location.

Soil samples were collected from each of the boreholes for field classification, headspace testing and chemical testing. Soil samples for general classification were obtained at depths of 0 to 1.5 feet, 1.5 to 3 feet, 3 to 4.5 feet and on 5-foot centers thereafter to boring termination. Boring depths generally ranged from 15 to 20 feet BLS. Soil samples were collected with a 24-inch long, 1.375-inch I.D. (2-inch O.D.) split spoon sampler. The samples were obtained by driving the sampler 18 inches using a 140-pound hammer, free falling for 30 inches, to deliver the blows required to drive the 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. Representative portions of each sample were placed in pre-labeled plastic bags and sealed for subsequent headspace testing and chemical analysis.

Remaining portions of 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 United Soil Classification System and a record of each test boring was produced. The soil test boring records along with a key to the symbols are presented in Appendix B.



The near surface soil encountered in the borings at Tank Farm A is a fine to medium sand with some areas containing silty sand. In order to perform a laboratory grain size distribution analysis on the fine to medium sand encountered at shallow depths, a representative sample (S-5) was collected at 13.5 to 15.0 feet BLS from 13GW19. The results of the grain size distribution analysis, which are presented in Appendix C, reveal that the sample contained 0.4% gravel, 92.6% sand and 7.0% silt/clay. In order to fully characterize soil types throughout the vertical extent of the surficial aquifer, a sample collected at 40 feet BLS from 13GW11 was submitted to the laboratory for grain size distribution analysis. The analytical results, which are presented in Appendix C, reveal that the sample contained 89.6% sand, 5.8% silt and 4.6% clay. Moist soil conditions were generally encountered at a depth of 8 to 10 feet BLS.

Soil encountered at a depth of approximately 47 feet BLS at 13B8 consisted of a dark grey clayey silty fine sand with shell fragments. This unit was identified based on samples retrieved from drill cuttings since split spoon sampling below a depths of approximately 20 feet were prevented by auger blow-in (heaving sands). This silty fine sand is characteristic of the upper confining unit of the Yorktown Formation as described in USGS Report 89-4200 (Murray, 1990b).

In order to provide for ease of lithologic interpretation, the two cross sections exhibited in Drawing 3.3 were developed for Tank Farm A. The cross sections, as developed from the boring records, are illustrated in Drawings 3.4 and 3.5. As shown in the cross sections, the soil types encountered appear to form a relatively homogeneous lithologic framework. Based on data produced in previous studies performed by USGS, it is



believed that the upper confining unit of the Yorktown Formation is continuous at the project site, although its depth may vary. The thickness of the unit reportedly ranges from 7 to 28 feet and appears to decrease in thickness to the south of Cherry Point MCAS (Murray, 1990b). As previously indicated, the upper confining unit was encountered in boring 13B8 at approximately 47 feet BLS.

3.4 Site Hydrogeology

A total of seventeen ground-water monitoring wells were constructed during this investigation utilizing the materials and installation procedures described in the CSA Workplan contained in Appendix A. These specifications included decontamination of the drilling equipment and well construction materials with a pressure steam cleaning unit, silica sand filter pack, bentonite seal above the filter pack, grouting with cement/bentonite slurry above the bentonite seal and well development via low yield pumping. Approximate volumes of water removed during development and observations of turbidity are listed in Table 3.1.

For wells constructed in grassed areas, wellheads are protected by a lockable, steel, stick-up cover. The stick-up cover is embedded in a concrete pad and is protected by three steel bollards filled with concrete. Wells constructed in traffic areas are flush mount protected by bolt-down steel cover plates and lockable plugs. Monitoring well installation details for Type II and Type III wells are included in Appendix D.



Depths to ground water were measured in all monitoring wells on November 6 and November 20, 1990. Results of these measurements are listed on the Monitoring Well Casing and Water Elevation Worksheets contained in Appendix E. Elevations of all measuring points were reviewed by a Registered Land Surveyor and are also listed in the Worksheets contained in Appendix E.

Based on ground-water elevations measured in the monitoring wells on November 20, 1990, a water table contour map was prepared and ground-water flow direction established as shown in Drawing 3.6. Ground water in the surficial aquifer generally flows across the project site in a northerly and northwesterly direction toward Slocum Creek. As indicated by a comparison of water level elevations recorded on November 6, 1990 in 13GW10 (screened from 5 to 20 feet BLS) and 13GW11 (screened from 35 to 40 feet BLS), ground water in the surficial aquifer appears to be moving laterally across the project site with no significant vertical gradient.

The rate or average linear velocity of ground-water movement across the project site is a function of the hydraulic conductivity (K) of the aquifer medium, the effective porosity (n) of the aquifer medium and the hydraulic gradient (dh/dl) that exists in the surficial aquifer. Hydraulic conductivity of the surficial aquifer at Tank Farm A was calculated based on results of previous studies performed on unconsolidated sands by F.D. Masch and K.J. Denny (Freeze and Cherry, 1979). Calculations involved the use of data provided by the grain size gradation curve (Appendix C) for sample S-5 collected from 13GW19. Results of these calculations show that one would expect hydraulic conductivity in the surficial aquifer to approximate 19.8 feet/day.

15' BLS.
DTW-10-43'



Average linear ground-water velocity in the surficial aquifer was calculated using a computer program (Water-Vel, 1989) designed to predict ground-water flow direction and flow rate based on piezometric (water table elevation) measurements, calculated value of hydraulic conductivity and estimated values for effective porosity. Program calculations are based on Darcy's Law ($q = K (dh/dl)$) and the relationship between Darcy velocity (q) and average linear ground-water velocity ($v = q/n$).

Using estimated values for effective porosity of 15% to 25% for fine sand (Walton, 1984), program results (Appendix F) reveal that average linear velocity is expected to range from 0.13 feet/day ($n=25\%$) to 0.22 feet/day ($n=15\%$). It is important to note that the values for effective porosity adopted herein are best estimated based on predominant soil types encountered during construction of borings at the project site. It should also be noted that the velocity calculated above is an average velocity across the entire project site and, therefore, the actual rate at a specific location at the site may be more or less than the rate calculated herein.

4.0 SUBSURFACE CONTAMINATION ASSESSMENT

4.1 Soil Contamination

All soil investigation activities were monitored with a HNu Systems, Model PI 101 Photoionization Detector (PID) calibrated to isobutylene, to determine the relative quantities of total volatile organics in the borehole, in ambient air, and in the individual soil samples. Values recorded with the HNu PID are qualitative only and not directly



comparable to actual laboratory analytical results. However, the HNu PID is very useful in providing a relative indication of the presence of volatile organics in soil samples.

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

- o The decontaminated split-spoon sampler was driven to the desired depth interval.
- o The split-spoon sampler was retrieved and immediately opened. Portions of sample aliquots were quickly removed from the split-spoon sampler and placed into two, pre-labeled, airtight plastic bags. Sample handling was executed carefully so as to minimize the loss of the volatile organics. The bags were sealed and placed in a warm (70^oF) location.
- o After approximately 20 minutes, the headspace gas in one of the two bags was tested with the HNu PID, and the peak value recorded. This procedure was conducted for soil samples collected at each sample depth interval.
- o From the soil samples collected from the borings, the sample that exhibited the highest soil headspace PID reading was selected for chemical analysis. For those samples, the paired sample was transferred to a laboratory-supplied glass container, placed into a cooler, packed on ice and shipped to the laboratory for chemical analysis. Custody of the samples was maintained by Law Engineering field staff until shipment at the end of each day.



Headspace sampling results are presented in Table 4.1. Results show that volatile organics were detected in samples collected from 12 of the 25 boreholes. With the exception of samples collected from 13GW9, concentrations of contamination were greatest at depths (8.5-15.0 feet) near the saturated soil zones.

Chemical testing results for the soil samples collected are summarized in Table 4.2. Although the headspace testing indicated the presence of volatile organics in 12 boreholes, the laboratory testing indicated the presence of low boiling point hydrocarbons (total petroleum hydrocarbons) in only 3 of the samples obtained for chemical testing (13B1, 13B6 and 13GW14).

It is important to note that laboratory analyses revealed the presence of kerosene in soil samples collected from 9 of the boreholes. Gas chromatography reveals that the hydrocarbon makeup and elution range of kerosene is very similar to that of jet fuels (Friedman, 1991). Therefore, it is possible that due to "weathering" processes, the jet fuel present in the subsurface has developed chemical characteristics similar to that of kerosene. Petroleum hydrocarbon and kerosene isopleth maps are presented in Drawings 4.1.1 and 4.1.2, respectively.

Based on knowledge of pre-existing free product in the vicinity of 13GW1, 13GW2, 13GW3 and 13GW4 and the newly acquired data with respect to soil contamination detected in 13B4, 13B6, 13B7 and 13GW23, it is apparent that a release of fuel in the vicinity of the eastern corner of Tank Farm A has produced some lateral movement of fuel throughout the eastern section of the project site. The data also suggest the



probability of additional releases of product in the vicinity of 13B3 and 13GW14. It should be noted that these data points are located directly adjacent to underground aviation fuel transmission lines (Drawing 2.1). Therefore, these lines are highly suspect as potential, contributing sources of subsurface petroleum fuel contamination in the vicinity of Tank Farm A.

4.2 Extent of Free Product

All Type II monitoring wells were constructed to allow for detection of free product in the capillary fringe area. As indicated on the Monitoring Well Casing and Water Elevation Worksheet presented in Appendix E, measurable free product was detected on November 20, 1990 in monitoring well nos. 13GW1, 13GW2, 13GW3, 13GW4, 13GW6, 13GW10, and 13GW14. Product thicknesses ranged from 0.55 feet in 13GW3 to 4.27 feet in 13GW2. No other monitoring wells indicated the presence of free product via probe measurement on November 6, 1990 or November 20, 1990.

Because of differences in the density and capillary pressures of water, oil and air, the measured thickness of free liquid hydrocarbons present in a well is usually greater than the actual thickness outside the well in the adjoining formation. Calculations performed in order to account for these differences reveal that actual product thicknesses in the formation may range from 0.22 feet surrounding 13GW3 to 1.7 feet surrounding 13GW2. Results are based on a 2.5:1 ratio of measured product thickness to true product thickness, which has been shown to be representative of fine sands (Lyman, 1990). These estimated product thicknesses are shown graphically in Drawing 4.2.



4.3 Dissolved Ground-Water Contamination

Ground-water samples were collected from each of the 25 monitoring wells. Prior to sampling, personnel donned laboratory grade gloves. These gloves were replaced after sampling each well to prevent cross-contamination. Prior to well sampling, the depths to ground water and free product (if present) 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 G).

All monitoring wells were evacuated 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 formation. The wells were evacuated using decontaminated Teflon bailers attached to new nylon cord. Specific conductance, pH, and water temperature were measured and recorded throughout the evacuation process. Well evacuation continued until three standing well volumes were evacuated and indicator parameters had stabilized (or until well exhibited dryness). 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 shipment at the end of each day.

A summary of analytical results related to ground-water sampling activities is presented in Table 4.3. Results show that ground water beneath Tank Farm A has been contaminated with typical petroleum fuel related hydrocarbons including benzene, toluene, ethylbenzene, xylenes, chlorobenzene, fluorene, phenanthrene, acenaphthylene



and naphthalene. The hydrocarbon contamination appears to be originating within the tank farm and at possibly as many as two additional locations outside of the tank farm compound. Due to the predominant ground-water flow direction, contaminants appear to be migrating in a northerly and northwesterly direction.

The rate at which these 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 conservative (greater than anticipated) estimates of contaminant migration rates at Tank Farm A. 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 selected an average linear ground-water flow velocity of 0.18 feet/day (mean value of those reported in Section 3.4). Resulting calculations contained in Appendix H show that the rate of benzene movement is estimated at 0.05 feet/day. By comparison, acenaphthylene (relatively hydrophobic compound) is estimated to migrate at a rate of 0.0007 feet/day. The migration rates of remaining organic constituents detected at Tank Farm A are likely to fall somewhere within the range bounded by benzene and acenaphthylene. It is important to note that these migration rates are only gross estimates and may vary considerably from actual field migration rates.



Contaminant isopleth maps showing concentrations of benzene, toluene, ethylbenzene, and total xylenes are presented in Drawings 4.3, 4.4, 4.5 and 4.6, respectively. An isopleth map for the total concentrations of these four hydrocarbons (BTEX) is presented in Drawing 4.7. With respect to hydrocarbon contaminants, the primary sources of contamination appear to be located along the northeast border of the tank farm compound with a high probability of additional sources in the vicinities of 13GW10 and 13GW14. As indicated previously, underground fuel transmission lines are located in the immediate vicinities of 13GW10 and 13GW14 and therefore, become suspect as likely sources of inadvertent releases or as preferential pathways for subsurface fuel movement.

Although lead concentrations are typically highest in wells containing free product, a consistent pattern of elevated lead concentrations does not exist at Tank Farm A (Drawing 4.8). Lead concentrations in the majority of wells which do not exhibit marked hydrocarbon contamination are generally less than 100 ug/l. However, 13GW5 and 13GW18 (no apparent hydrocarbon contamination) exhibit lead concentrations of 244 ug/l and 168 ug/l, respectively. Alternatively, several wells (13GW1, 13GW4, 13GW10) which do exhibit significant hydrocarbon contamination show relatively low concentrations of lead. In summary, we are not able to draw any conclusions regarding the probable relationship between lead concentrations detected at Tank Farm A and migration patterns of water-borne lead resulting from petroleum fuel releases.

In order to monitor ground water at multiple depths and delineate the vertical extent of ground-water contamination at Tank Farm A, a well pair was installed consisting of 13GW10 and 13GW11. Monitoring well 13GW11 is a EPA Type III ground-water well



consisting of a five foot screen located at a depth interval of 35 to 40 feet BLS. Monitoring well 13GW10 is a EPA Type II ground-water well screened from 5 to 20 feet BLS. Although sampling results associated with 13GW10 suggest that ground water present in the upper saturated zone near-surface sediments (8-20 feet BLS) is moderately contaminated, only benzene (at a barely detectable concentration of 2 ug/l) was detected in 13GW11. Therefore, it appears that contamination at Tank Farm A may be confined to the upper portions of the surficial aquifer.

5.0 QUALITY CONTROL PROCEDURES

5.1 Equipment Decontamination

Quality control procedures for equipment handling and decontamination are detailed in the CSA Workplan (Appendix A). As outlined in the Workplan, decontamination of drilling equipment was performed at Tank Farm E. A sample of the base potable water was collected from the spigot located at Tank Farm E and tested for purgeable aromatic hydrocarbons. Laboratory results (identified as "MW-1 Faucet" in Appendix I) exhibited no detectable concentrations of benzene, toluene, ethylbenzene or xylenes.

5.2 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 Tank Farm A, three quality control



measures were employed. First, an equipment rinse blank was submitted to the laboratory for evaluation of procedures used to decontaminate the Teflon bailers. Second, two trip blanks were submitted to the laboratory to perform checks on the integrity of the sample containers and ascertain whether contaminants may have entered the sample containers during shipment to and from the job site. Third, two duplicate ground-water samples and one duplicate soil sample were collected as a check on sampling technique and reproducibility of laboratory testing procedures. Laboratory quality controls included the use of lab blanks throughout the analytical procedures to check for laboratory induced contamination.

Based on discussions with laboratory personnel and detection of methylene chloride in several laboratory blank samples, it is apparent that methylene chloride which was detected in one trip blank, the rinse blank and several ground-water samples collected from Tank Farm A is a laboratory induced contaminant. Methylene chloride is a commonly used laboratory cleaning agent and we have no reason to suspect that it is present in ground water beneath Tank Farm A.

Although methylene chloride, toluene and xylenes were detected in the rinse blank, analysis revealed that bailer decontamination procedures were successful in eliminating the introduction of contaminants via sampling equipment. As previously indicated, methylene chloride is considered to be a laboratory induced contaminant. Based on the relatively low concentrations of toluene (0.4 ug/l) and xylenes (2.0 ug/l) detected, we believe that no significant petroleum hydrocarbon contamination of ground-water samples occurred as a result contaminated sampling equipment. Based on an opinion by laboratory personnel that low levels of toluene (0.5-3.0 ug/l) and xylenes (0.9 ug/l)



oftentimes occur due to laboratory-induced contaminants, we believe that the rinse blank was relatively free of petroleum hydrocarbon contamination upon receipt by the laboratory.

Because 1,1,1-trichloroethane was detected in both trip blanks at near the detection limit, it may be reasonable to suspect that this compound was either present in the trip blank preparation water or was introduced to the samples during shipment and storage prior to sample collection. In either event, its presence in the trip blanks is not indicative of 1,1,1-trichloroethane contamination of the ground water at Tank Farm A.

5.3 Chemical Data Evaluation

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Tucci*

In order to assess the quality of laboratory produced data, a chemical data evaluation or analytical data review was performed. The evaluation included a review of surrogate failures, calibration verification, holding times, organic blank contamination, documentation and sample condition. In summary, the evaluation results indicate that reported discrepancies between actual results/procedures and standard results/procedures are not considered to have major impact on the data reported. A copy of the analytical data review report is included in Appendix J.



6.0 POTENTIAL RECEPTORS SURVEY

Fuel contamination, in any one of four physical states or "phases" (residual, vapor, liquid, dissolved), may be transmitted to receptors via ingestion, inhalation, or absorption. As petroleum fuel seeps into 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 take 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 6.1.

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. However, based on headspace and laboratory tests results, petroleum contamination is not generally present in near-surface soil at Tank Farm A. As indicated in Section 4.1, soil contamination is present only at depths below approximately 8 feet BLS. As a result, 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. The only active water supply well included in the well survey is Cherry Point MCAS drinking water supply well no. 9 located approximately 2000 feet west of Tank Farm A. Results of a recent water supply/water quality study conducted by USGS (Lloyd, 1988) revealed that water supply well no. 9 did not contain organic contaminants. The list of test parameters included benzene, toluene, acenaphthylene, naphthalene, fluorene, phenanthrene and ethylbenzene, all of which were detected in the surficial aquifer at Tank Farm A. Other Cherry Point MCAS drinking water supply wells in the general site vicinity are shown in Drawing 2.2.

Subsurface contaminants have been known to find their way into buried water supply lines primarily through direct contact with free product (liquid phase hydrocarbons). Therefore, potential exposure to contaminants via contamination of drinking water in the water mains along the northeastern boundary of Tank Farm A and along the northeastern side of building 1016 was considered. However, contamination of this



water via contact with subsurface contaminants is unlikely since the mains are reportedly constructed of cast-iron with leaded joints and are located several feet above the accumulated free product.

According to a representative of Jones Operation and Maintenance Company (fuel farm management contractor), no basement structures nor vaults or manways used for routine maintenance are located within the Tank Farm A compound. However, several subsurface utilities are located outside of the tank farm compound in the vicinity of accumulated free product. Therefore, a vapor phase survey of accessible confined spaces was performed using the HNu PID. These spaces included a storm sewer drop inlet and an electrical vault, both located approximately midway between 13GW9 and 13GW14. Additionally, a manway located along the southeastern side of building 250 and marked for access to electrical conduits was also screened for volatile organics. No volatile organics were detected in any of these confined spaces. Further inspection of building nos. 250 and 1008 revealed that no means of access to the subsurface (manways, vaults, etc.) are located within these buildings.

The results of the potential receptors survey indicate that the presence of contaminants in the subsurface at Tank Farm A does not constitute an imminent or near-future health threat to potential receptors. However, it is possible that organic vapors may be present along portions of subsurface utilities which may possibly result in exposure during maintenance and repair activities.



7.0 REMEDIAL ALTERNATIVES AND RECOMMENDATIONS

Due to the spatial distribution of free product (liquid phase) and petroleum hydrocarbon contamination in soil (adsorbed phase) and water samples (dissolved phase) collected from Tank Farm A, it appears that several isolated releases of petroleum fuel have occurred at the project site. However, the timing of the releases is uncertain and we cannot rule out the possibility of an ongoing release. Therefore, as an initial step in the remedial process, we recommend that the integrity of the fuel storage and distribution system be thoroughly evaluated.

7.1 Soil Remediation

7.1.1 Overview and Soil Remediation Objectives

Primary reasons for soil remediation at sites involving leaking underground petroleum fuel storage tanks include protection of public health and protection of ground-water quality. As discussed in Section 6.0 of this report, the potential for exposure to contaminated soil at Tank Farm A is relatively nonexistent as long as the subsurface remains undisturbed. However, guidelines for remediation of soil contaminated by petroleum have been established by NCDEHNR, Division of Environmental Management, Ground Water Section. Within these guidelines, the Ground Water Section has set an "action level" of 10 mg/kg of TPH and a maximum contaminant concentration of 85 mg/kg of TPH. Therefore, the objectives for remediation of contaminated soil at the project site should focus on elimination of the adsorbed hydrocarbons as an ongoing source of ground-water contamination via leaching and



desorption and to comply with NCDEHNR guidelines which require remediation of all soil containing greater than 85 mg/kg of TPH. At sites where ground water is particularly vulnerable to contamination via leaching or where contaminated soil is in direct contact with ground water, required cleanup levels may be as stringent as 10 mg/kg of TPH, depending on the depths and characteristics of the contamination.

7.1.2 Survey of Petroleum Contaminated Soil Remediation Technologies

This section of the report serves to provide a brief introduction to the technologies considered for treatment of contaminated soil at Tank Farm A. The technologies may be conveniently separated into in-situ methods and non in-situ methods. In-situ technologies involve remedial methods in which contaminated soil is treated in place. In-situ technologies do not require the removal of contaminated soil. However, limited excavation may be required to install and operate an in-situ technology. Our survey includes consideration of the following in-situ technologies: enhanced bioreclamation; isolation/containment; leaching and chemical reaction; natural attenuation; vitrification; and volatilization (vacuum extraction). These technologies are introduced in sections 7.1.2.1 through 7.1.2.6. The primary advantages of in-situ technologies include minimal site disturbance, minimal exposure during remediation activities and avoidance of potential liabilities associated with off-site transport and disposal.

Non in-situ technologies involve remedial methods which require the removal (excavation) of contaminated soil. Soil treatment may be conducted on site and/or off site depending on the requirements of the particular technology. This survey includes consideration of the following non in-situ technologies: low temperature thermal



reduction; incineration; land application; and enhanced volatilization (surface treatment) and/or composting. These technologies are introduced in sections 7.1.2.7 through 7.1.2.10. Disposal of untreated soil by landfilling is mentioned in section 7.1.2.11. The primary advantages of non in-situ technologies include immediate or short-term resolution of the problem at the contamination site, ability to meet target cleanup levels with higher degree of certainty assuming all contaminated material is capable of being excavated and widespread practice within the remediation industry (except for landfilling of untreated soil).

7.1.2.1 Enhanced Bioreclamation

Enhanced bioreclamation is a process in which measures are taken to aid the growth and metabolism of microorganisms in degrading petroleum constituents present in soil. Although the organisms occur naturally, effective use of this technology often requires the addition of nutrients and oxygen to enhance the degradation of the petroleum.

Enhanced bioreclamation is often used in conjunction with ground-water remediation efforts. Typically, ground water is extracted from the subsurface using recovery wells and a pumping system. The extracted ground water is mixed with nutrients and an oxygen source and re-introduced into the subsurface via an infiltration gallery located above or upgradient of the contaminated area. The nutrient rich water percolates through the contaminated soil under the influence of gravity until it reaches the ground-water table where it then migrates toward the ground-water extraction system. As the



nutrient rich water percolates through the petroleum contaminated soil, the metabolism of the petroleum consuming microorganisms is stimulated resulting in consumption of petroleum hydrocarbons.

7.1.2.2 Isolation/Containment

The process of isolation/containment typically involves the installation of subsurface walls to preclude further migration of the contaminants. The walls are usually constructed of slurry or grout and may be located upgradient and/or downgradient of the contaminated soil. These walls may be used in conjunction with a "cap" which is located upon land surface above the contaminated soils. The "cap" is intended to impede the migration of contaminants resulting from the infiltration of precipitation. It is important to note that this technology does not actively destroy or reduce hydrocarbon concentrations in the soil.

7.1.2.3 In-Situ Leaching and Chemical Reaction

This process entails flushing hydrocarbons from the soil with water or, more typically, a water-surfactant mixture. The water-surfactant mixture is applied by spray irrigation (or similar technique) upon the land surface above the soil contaminated by petroleum. As the mixture leaches through the soil, adsorbed hydrocarbons are extracted from the soil. The water-surfactant and hydrocarbon mixture leach through the soil under the influence of gravity until the mixture reaches the ground-water table or a confining layer.



The infiltration water or mixture is extracted from the subsurface by means of a pumping system . The extracted ground water will require treatment to remove the hydrocarbons and the surfactant prior to discharge.

7.1.2.4 In-Situ Passive Treatment/Natural Attenuation

This technology involves "no action" to address petroleum contamination of the soil. This remedial method relies on naturally occurring processes such as dispersion and biodegradation to reduce the concentrations of the hydrocarbons.

7.1.2.5 In-Situ Vitrification

In situ vitrification entails the use of electricity to change the hydrocarbon laden soil from its natural semi-solid phase into a molten liquid phase which ultimately cools to a glass-like solid phase. Most hydrocarbons within the soil are volatilized during the phase change and any remaining hydrocarbons are encapsulated within the glass-like end product of this technique.

7.1.2.6 In-Situ Volatilization (Vacuum Extraction)

This technology exploits the natural tendency of some hydrocarbon compounds to volatilize. Pressurized volatile free air is introduced (via vapor introduction wells) into the zone of contaminated soil. The volatile hydrocarbons migrate from the areas of high concentration (on the soil particles) to areas of low concentration (fresh volatile free air injected into the subsurface). As the concentrations of volatiles within the injected air



increase, the air is extracted (via vapor extraction wells) from the subsurface ultimately reducing the volatile hydrocarbon concentrations within the subsurface. The extracted volatile hydrocarbon laden air may require treatment.

7.1.2.7 Low Temperature Thermal Reduction (LTTR)

LTTR is a process in which petroleum hydrocarbons are driven from the soil through enhanced volatilization by the application of heat. The excavated soil may be treated by LTTR either on site or the soil may be transported and treated off site. The treated soil may be used as backfill or it may be used as a raw material in asphalt or brick manufacturing operations.

7.1.2.8 Incineration

Incineration is a non in-situ technology which employs high temperature (at least 1000^o C for a minimum of two seconds) combustion of organics (petroleum hydrocarbons) present in soil. The incineration process can be conducted on site or off site. The end products of this treatment alternative include ash and scrubber water (a by-product of the cooling process) both of which may require disposal permits.

7.1.2.9 Land Application

Land Application of petroleum contaminated soil involves the distribution of the excavated soil over the land surface. The petroleum laden soil is spread to a thickness of one to twelve inches and mixed with the natural soil using earth moving and



conventional farm equipment. Nutrients are typically incorporated into the treated soil. Hydrocarbon concentrations are attenuated primarily by volatilization and biodegradation.

7.1.2.10 Enhanced Volatilization (Surface Treatment) and/or Composting

This technology is similar to land application (Section 7.1.2.9), however, the excavated contaminated soil is spread upon an impermeable layer (e.g., plastic) to prevent contact between contaminated soil and native soil. In addition to the tilling that is required to enhance volatilization, the soil can be composted to enhance the reduction of hydrocarbons. As with land application, hydrocarbon concentrations are attenuated primarily by volatilization and biodegradation.

7.1.2.11 Landfilling

Landfilling simply requires the excavation of contaminated soil and transportation to the landfill. Hydrocarbons are not actively removed from soil when this disposal method is used exclusive of treatment. This method is not recommended due to the possibility of cross-contamination at the disposal site thereby creating potential future liabilities for cleanup at the disposal site.



7.1.3 Preliminary Recommendation for Soil Remediation

The eleven technologies introduced in Section 7.1.2 were briefly evaluated for their application to the Tank Farm A site and with respect to technical, institutional, environmental, health and economical considerations. Because of the moderately thick vadose zone and the presence of impermeable surfaces over much of the project site, remediation of contaminated soil in the vadose zone caused by near-surface releases may be most effectively accomplished by means of enhanced, in-situ volatilization techniques (Section 7.1.2.6). The course-grained soils encountered at the project site may provide conditions conducive to generation of sufficient air flow for enhanced volatilization via vacuum extraction technology.

The first step in the soil remediation process will be to further identify the extent of vadose zone contamination in the areas of suspected releases. These suspected areas are discussed in Section 4.1. Once the extent of soil contamination is identified, a vacuum extraction pilot test should be performed to determine the feasibility and efficiency of such an extraction system. The pilot test should be performed within the project site or in an area with similar subsurface conditions. The test area should be covered with an impervious layer (synthetic liner, asphalt, concrete) to prevent "short-circuiting" of air flow patterns which may result in limiting the movement of air to the immediate vicinity of the extraction wells.

*Parameters to measure vacuum around
vacuum site.*



7.2 Free Product Removal

As discussed in Section 4.2, measurable free phase product (liquid hydrocarbons) was encountered during this investigation in the areas exhibited in Drawing 4.2. Recovery of free phase product from the water table is relatively common at sites which exhibit substantial thicknesses of liquid hydrocarbons. A brief description of free product recovery alternatives is contained in the survey of ground-water and free product extraction technologies presented in Section 7.3.2 of this report.

The most promising method of free product removal at sites with characteristics similar to Tank Farm A is through utilization of recovery wells. This method requires the installation of a pumping well(s) of typically four to six inches in diameter. The well(s) would be designed to house either a total fluids or liquid phase hydrocarbon pump in order to remove free product from the subsurface. This process would require temporary storage of recovered product and treatment/discharge of contaminated wastewater. Free product recovery should continue as long as recoverable product is present in the subsurface.

The extraction of product via recovery wells requires installation of conduit extending from the wellhead to a product storage tank. In order to reduce the likelihood for damage and in some cases, prevent freeze-up, conduit is typically buried below ground surface. In the case of Tank Farm A, burial would also be required to eliminate interference with aircraft traffic on the runway apron. Therefore, special design considerations will be necessary to ensure that wellhead and conduit construction does not interfere with runway operations.



7.3 Ground-Water Restoration

7.3.1 Overview and Ground-water Remediation Objectives

As indicated by data presented in Section 4.3, dissolved hydrocarbon plumes have apparently developed as a result of leaks, spills, discharges, etc. at Tank Farm A and appear to be extending in a northerly and northwesterly direction. The necessity of remediation efforts designed to restore ground water is often not an easy decision to rationalize. In the absence of a specific regulatory requirement, the decision ultimately rests upon 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, in a situation where the risk to public health or welfare is unavoidable and unacceptable as a result of exposure to ground-water contaminants, remediation is warranted. As indicated in Section 6.0 and Table 6.1 of this Report, present exposure to ground-water contaminants in the vicinity of Tank Farm A is considered unlikely. However, recent USGS studies have shown evidence of deep well contamination in several wells at Cherry Point MCAS which is believed to have originated from near-surface waste disposal practices.

With respect to regulatory requirements, the North Carolina Environmental Management Commission (EMC) has adopted maximum allowable concentrations for contaminant constituents in ground water. For compounds detected in ground water beneath Tank Farm A, the maximum concentrations are listed in Table 4.3. For compounds which do



not have a numerical standard (e.g., acenaphthylene, fluorene, phenanthrene and naphthalene), a petition may be filed with the North Carolina Division of Environmental Management (DEM) in order to establish such a standard. As indicted by comparison, acenaphthylene, fluorene, phenanthrene, chlorobenzene, trichloroethene, benzene, ethylbenzene, lead, naphthalene, toluene and xylenes were detected in concentrations in excess of the maximum allowable concentrations. Rules adopted by the EMC and enforced by DEM require that "any person conducting or controlling an activity which results in an increase in the concentration of a substance in excess of the groundwater standard shall.....submit a plan for eliminating the source of contamination and for restoration of ground-water quality....". Therefore, compliance with North Carolina Administrative Code (15NCAC2L) necessitates the restoration of ground waters beneath Tank Farm A to a quality as near to the standards as is technologically feasible.

7.3.2 Survey of Ground-Water and Free Product Extraction Technologies

7.3.2.1 Overview

The majority of available technologies associated with the restoration of hydrocarbon contaminated aquifers implement "pump and treat" techniques. That is, ground water and free product are pumped from the subsurface. Free product is typically separated from the extracted liquid and delivered to a storage tank. Ground water is treated by aboveground physical, chemical and/or biological means prior to discharge. The following discussion will address the three basic tasks involved with the restoration of an aquifer when using "pump and treat" methodologies. These tasks include (1) the



extraction of the ground water from the aquifer; (2) the treatment technology(ies) implemented to reduce the concentrations of the contaminants within the extracted ground water; and (3) disposal of the treated water.

In order to implement a "pump and treat" technology the adversely impacted ground water must be extracted from the aquifer. The extraction process serves three purposes. First it provides a means of removing free product from the subsurface. Second, it delivers the contaminated ground water from the aquifer to the treatment equipment. Third, the extraction process is used to control, reduce or eliminate further migration of the contaminant plume within the aquifer.

7.3.2.2 Extraction Wells

Extraction wells are essentially hollow pipes installed in boreholes which extend vertically downward penetrating the aquifer which contains free product and contaminated ground water. The hollow pipe, referred to as casing, is generally constructed of PVC or stainless steel and may vary in diameter from two inches to two feet, or larger (wells within large casings are often referred to as sumps). The casing diameter is less than the borehole diameter and annular space between the two is filled with a hydraulically conductive material (e.g. sand, gravel, etc.) over and slightly above the screened section. The remainder of the annular space between the sand pack and land surface is grouted to prevent entry of contaminants from land surface. Typically the portion of the casing which penetrates the aquifer is slotted casing. This permits ground water and free product to accumulate within the casing. The accumulated fluids can be extracted by means of a pump and delivered to the treatment system.



Continuous pumping from the well lowers the static water level elevation in the vicinity of the well. The pumping produces a cone of depression upon the water table around the well which alters normal ground-water flow patterns. Fluids tend to flow towards the well being pumped. Thus, the fluids targeted for recovery and treatment can be captured by judicious use of pumping wells.

The effectiveness of pumping wells is dependent upon site specific conditions. The characteristics of the impacted aquifer will dictate the effectiveness of ground-water extraction by means of pumping wells.

Advantages:

- Once Installed, extraction wells are unobtrusive.
- Can be effective in shallow as well as deep aquifers.
- Economical.

Disadvantages:

- Low aquifer conductivity can severely limit the area influenced by pumping the extraction well.

7.3.2.3 Trenches/Drains

Trenches used in applications for permanent systems, as opposed to temporary or emergency situations, can be thought of as horizontal wells. A trench is excavated to a depth which penetrates the target aquifer. Perforated pipe (drain) is placed within the trench and is linked to a vertical standpipe. The entire trench is backfilled with a material



characterized by high hydraulic conductivity (sand, gravel, etc.). Water/petroleum is extracted by means of a pump located in the standpipe which draws fluids from the trench system.

Trench recovery systems are typically located downgradient of the contaminant source. As the contaminants migrate under the influence of natural ground-water flow, they are intercepted by the downgradient trench. These interceptor trenches are useful in situations where the velocity of the contaminant plume requires expedient aquifer restoration.

If pumped at sufficient rates, trenches may be used to depress the water table and alter natural ground-water flow to benefit the restoration of the aquifer in a fashion similar to recovery wells.

- Advantages:
- Use of recovery trenches may expedite aquifer restoration when compared to other extraction methods under certain circumstances.
 - May be more effective than wells in aquifer of very low yield.
 - Useful in emergency situations to quickly capture migrating free product.



- Disadvantages:
- The contaminated portion of the aquifer must be relatively close to land surface.
 - Soil excavated during trench installation may require special disposal, if contaminated.
 - Installation of trenches may be obtrusive to normal site activities and underground utilities may present difficulties with trench placement and construction.

7.3.2.4 Pumping Technologies

Pumps typically used for the extraction of ground water and petroleum are usually pneumatically or electrically driven. They may be set to skim free phase petroleum from the water table, pump total fluids (petroleum and ground water) or operate in pairs (water table depression pump coupled with a free product pump). Each of these pump systems may be used in conjunction with extraction wells or trenches.

Skimmer Pumps

- Advantages:
- Does not mix water with the petroleum.
 - Inexpensive; may be operated with or without a power source in remote locations.

- Disadvantages:
- Can only be used effectively in open ditches, sumps (large diameter wells) or trenches.
 - The volume of the aquifer influenced by these pumps is limited.



Total Fluids Pumps

- Advantages:
- Applicable to wells and trenches.
 - Capable of displacing large quantities of fluids over large distances.
 - Capable of influencing relatively large aquifer volumes.

- Disadvantages:
- May emulsify petroleum and water.

Pump Pairs

- Advantages:
- Same as total fluid pump.
 - Does not emulsify petroleum and water.

- Disadvantages:
- Pump operation is complicated and sensitive to fluctuations in levels of free product and ground water.
 - Expensive.

7.3.3 Survey of Ground-Water Treatment Technologies

7.3.3.1 Oil/Water Separators

Oil/water separators, as the name implies, are used to separate free phase and suspended petroleum from the extracted ground water. These units are essentially tanks which contain a series of baffles which segregate the fluids. Typically, the oil (petroleum) is decanted from the unit and stored in a separate tank for recycling or



disposal. The effluent ground water may undergo further treatment prior to discharge pursuant to regulatory permit.

- Advantages:
- Provide effective pre-treatment of ground-water which may contain free product (petroleum).
 - Aid in minimizing fouling of subsequent treatment equipment.

- Disadvantages:
- Treatment by this method alone usually does not reduce influent contaminant concentrations (dissolved phase) sufficiently for disposal (i.e., not effective as a stand alone treatment).

7.3.3.2 Packed Tower Air Stripping

Packed towers consist of a rigid cylindrical column or tower which usually extends vertically upward from land surface. The dimensions of the tower are dependent on the air to water ratio required for effective treatment. Typically, towers range from 1.5 to 4 feet in diameter and 10 to 30 feet in height. The tower, which resembles a smoke stack, is often constructed of fiberglass, aluminum or steel. The tower is filled with a packing material designed to provide a large surface area for purposes for enhancing water to air transport (volatilization) of organics.

The extracted ground-water, containing dissolved contaminants, is pumped to the top of the tower and sprayed over the packing material. Concurrently, air is forced from the bottom of the tower upwards through the tower by means of a blower, thus creating a ground water-air counter flow over the large surface area created by the packing



material. The treated water, which collects at the bottom of the tower, is routed for further treatment or direct discharge under regulatory permit. The injected air is typically vented to the atmosphere from the top of the tower.

The petroleum hydrocarbons dissolved within the ground water come into intimate contact with the clean, injected air. The petroleum hydrocarbons have a propensity to move from media of high concentration (ground water) to media of low concentration (air). The transfer of the petroleum hydrocarbons from the ground water to the injected air is enhanced by the high Henry's Law constant which characterizes many petroleum hydrocarbons.

Reductions in petroleum concentrations within the ground water achieved with packed tower air stripping have been reported as high as 95-99 percent. When necessary, water treatment by oil-water separation or chemical treatment may proceed packed tower air stripping. Post air stripping treatment may be required depending upon effluent discharge limitations.

- Advantages:
- Stripping towers can effectively remove large percentages of dissolved hydrocarbons.
 - A proven technology generally accepted by regulatory agencies.
 - Relatively inexpensive.



- Disadvantages:
- Large obtrusive towers may be aesthetically displeasing.
 - Treatment of effluent air may be required.
 - Further treatment or "polishing" of effluent water may be required prior to discharge.
 - Subject to fouling by inorganic compounds.

7.3.3.3 Trickle Tray Air Stripping

Trickle tray air strippers treat petroleum contaminated ground water implementing the same technology described for stripping towers. However, the trickle tray approach routes the influent water over a stack of trays which contain a high surface area media. Air is blown into the system, mass transport occurs across the air-water interface and the petroleum laden air is vented to the atmosphere.

- Advantages
- The design is compact and less obtrusive than tower designs.
 - Capable of producing high removal rates.

- Disadvantages
- Treatment of effluent air may be required.
 - Further treatment or "polishing" of effluent water may be required prior to discharge.
 - Subject to fouling by inorganic compounds.



7.3.3.4 Diffusion Air Stripping

This method also works on the principle of removing petroleum hydrocarbons from the ground water by transport to fresh air. However, the diffusion technique does not implement a counter flow approach as with towers and trays.

Extracted ground water is pumped into a vat (ranging in size from a 55-gallon drum to 200+ gallon concrete vaults). Water within the vat is vigorously aerated by forcing compressed or blower driven air through a diffuser at the bottom of the vat. As the air rises through the water in the vat, the petroleum hydrocarbon compounds transfer from the water (high petroleum concentration) to the air bubbles (low petroleum concentration). When the bubbles reach the water surface, the petroleum hydrocarbons are released to the atmosphere. The effluent water may be discharged or further treated, if necessary.

- Advantages:
- Equipment is easy to operate; low maintenance.
 - High removal efficiencies possible.
 - Can be installed below grade thereby minimizing freeze-up problems and aesthetic concerns.
 - Relatively low cost.



- Disadvantages:
- Treatment of effluent air may be required.
 - Method is a new application for an existing technology and may be unfamiliar to the regulatory agencies.
 - Further treatment or "polishing" of effluent water may be required prior to discharge.
 - If installed below grade, additional regulatory monitoring requirements may apply.

7.3.3.5 Ultrafiltration/Reverse Osmosis

This method employs a technique by which the petroleum laden ground-water is forced through a semi-permeable membrane. Water passes through the membrane but the petroleum and other substances in the water cannot pass through the membrane. The petroleum and other substances are decanted off and require disposal. The water which passes through the membrane is usually treated sufficiently for direct discharge under regulatory permit.

- Advantages:
- Effectiveness of petroleum removal is high.
 - Equipment is generally unobtrusive.

- Disadvantages:
- Often up to 10% of influent volume is filtered out and requires special handling for disposal.
 - Maintenance intensive.
 - Expensive.



7.3.3.6 Carbon Adsorption

Granulated activated carbon (GAC) is used for carbon adsorption technologies. The extracted ground water is pumped into GAC reactors. The reactors operate at or above atmospheric pressure depending on equipment design. Within the reactor, the petroleum laden ground water comes into intimate contact with the GAC. The petroleum hydrocarbon molecules within the ground water are attracted to the GAC and physically bond to the GAC. Water exiting the reactor or reactor series is typically treated sufficiently for disposal under strict regulatory permit requirements.

- Advantages:
- Very effective at removing target compounds.
 - Effective when used to "polish" water treated by other methods.
 - Widely accepted by regulatory agencies.

- Disadvantages:
- Disposal/regeneration of spent GAC required.
 - Expensive, particularly if used as a stand alone treatment method.

7.3.3.7 Enhanced Bioreclamation

Enhanced bioreclamation is a process in which measures are taken to aid the growth and metabolism of microorganisms which degrade petroleum constituents present in ground water. Although the organisms occur naturally, effective use of this technology



often requires the addition of nutrients and oxygen to enhance the degradation of the petroleum.

Enhanced bioreclamation is often used in conjunction with soil remediation efforts. Typically, ground water is extracted from the subsurface, allowed to undergo physical and/or biological treatment in an aboveground "bioreactor", mixed with nutrients, oxygenated and re-introduced into the subsurface via an infiltration gallery located above or upgradient of the extraction system. The nutrient-rich water percolates through the soil under the influence of gravity until it reaches the water table where it then migrates toward the ground-water extraction system. As the nutrient-rich water reaches the water table, the metabolism of the petroleum consuming microorganisms is stimulated resulting in consumption of petroleum hydrocarbons.

- Advantages:
- Can be used in conjunction with soil remediation efforts.
 - Closed loop system eliminates potential liabilities associated with off-site discharges.
 - Does not produce troublesome byproducts of treatment (e.g., off-gases and spent carbon).

- Disadvantages:
- Requires pilot or "biofeasibility" study(ies).
 - Introduction of limiting nutrients to the ground water may be met with some regulatory resistance.
 - Low permeable soils inhibit effectiveness.
 - Requires high degree of maintenance and close supervision.



7.3.4 Survey of Disposal Technologies

7.3.4.1 Storm Sewer/Surface Waters

Disposal of the effluent water of the treatment system to storm sewers or surface waters requires a National Pollutant Discharge Elimination System (NPDES) permit.

Advantages:

- Storm sewer systems often accessible in urban areas and surface waters often accessible in rural areas.
- Operations are relatively maintenance-free.

Disadvantages:

- Permit processing is lengthy.
- Effluent quality stipulated by regulatory permit requirements may be difficult to achieve.

7.3.4.2 Sanitary Sewer

Disposal of the treatment system effluent water to the sanitary sewer will typically require a discharge permit from the receiving publicly owned treatment works (POTW).

Advantages:

- Sanitary sewer systems often accessible in urban areas.
- Treatment requirements often less restrictive than those for NPDES permits.
- Operations are relatively maintenance-free.



Disadvantages: - Permit availability and requirements subject to the capacity of the local POTW.

7.3.4.3 Land Application/Infiltration Galleries

Land application disposal (e.g., spray irrigation or infiltration galleries), where the treated water is discharged back into the subsurface, requires a North Carolina "non-discharge" permit.

Advantages: - Can be used to create a closed loop system thus eliminating potential liabilities associated with discharging of waste water off-site.

Disadvantages: - Subject to site soil conditions which affect required surface and subsurface loading rates.
- Space requirements.
- May require periodic maintenance.

7.3.4.4 Industrial Waste-Water Treatment Works

In industrial situations, extracted ground water may be incorporated into industrial waste water treated by the on-site waste-water treatment facility.



- Advantages:
- Typically an economical disposal method.
 - May eliminate or minimize treatment of extracted ground water prior to discharge.
 - May eliminate the need for additional regulatory permitting associated with discharge.

- Disadvantages:
- May require modifications to existing waste-water processing methods and monitoring requirements.
 - May require modifications to existing discharge permits.

7.3.4.5 Plant Process Make-up Water

For industrial situations, the extracted ground water can be used as make-up water for the plant process water system. In these situations, the extracted ground water is used to make up water lost during ordinary system processes (e.g., boiler blow-down, evaporation, etc.).

- Advantages:
- Typically an economical disposal method.
 - May eliminate or minimize treatment of extracted ground water prior to discharge.
 - May eliminate the need for additional regulatory permitting associated with discharge.
 - Will not increase load on existing waste-water treatment system.



Disadvantages: - Make-up water quality requirements may mandate extensive pretreatment of ground water prior to disposal into process water system.

7.3.5 Preliminary Recommendation for Ground-Water Restoration

Because adsorbed-phase (soil contamination) and liquid-phase (free product) hydrocarbons represent an on-going source of dissolved phase (ground water) contamination and because pumping systems can result in further spreading of liquid-phase hydrocarbons if not properly designed, it is recommended that free product removal be performed and substantially completed prior to implementation of ground-water remediation efforts, particularly in the areas where free product is present. It may be feasible, however, to begin ground-water restoration efforts in hydraulically downgradient areas so as to retard further dissolved-phase plume migration. Likewise, soil remediation efforts should be completed (non in-situ methods) or in process (in-situ methods) at the time ground-water remediation efforts commence.

Based on the nature of the contaminants and the potential for further treatment by the Cherry Point MCAS waste-water treatment system, packed tower air stripping (Section 7.3.3.2) or air diffusion (Section 7.3.3.4) may represent the most cost-effective means of ground-water treatment at the project site. The system may be designed so that ground water from multiple extraction wells is delivered to a central treatment unit with treated effluent discharged through a nearby tap to the waste-water treatment system. As



discussed in Section 7.2, the presence of the concrete runway apron adjacent to Tank Farm A will necessitate special design considerations in order to enable extraction of ground water from areas north and east of the tank farm.

Because conventional pump-treat-discharge systems may not be effective in completely restoring the aquifer and will not directly address residual soil contamination present in the capillary fringe area, consideration should also be given to enhanced bioreclamation technology (Section 7.3.3.7). The physical characteristics of the site appear to be well-suited for implementation of this technology in view of the coarse-grained soils; relatively secure areas for construction of infiltration systems; and moderately thick vadose zone to allow for adequate percolation of treated ground water. Further evaluation of this technology involves the performance of staged biofeasibility studies which will evaluate the presence of natural hydrocarbon-consuming bacteria, the potential toxicity of the site to such bacteria, nutrient availability and the ability of the site to support growth of bacterial populations.

7.4 Additional Data Needs For Remedial Action Plan Development

Development of an effective remedial action plan for restoration of subsurface conditions at Tank Farm A relies upon the following:

- o An identification of past or ongoing sources of contamination which includes testing and monitoring of existing fuel storage and distribution network.



- o Definition of the spatial extent of vadose zone contamination resulting from near surface discharges of petroleum.
- o Additional data with which to develop a more precise definition of the spatial extent of measurable free product accumulation.
- o Confirmation of vertical extent of dissolved-phase hydrocarbons in vicinity of 13GW14.
- o Results of an aquifer test to evaluate critical aquifer parameters and identification of critical inorganic water quality parameters, should remedial objectives include ground-water restoration.

7.5 Recommendations

- o Testing of subsurface, confined spaces in the vicinity of free product accumulation for evidence of volatile organic vapors and potentially explosive gas levels prior to entry for maintenance or repair.
- o Identification of possible ongoing releases through fuel system checks, inspection and testing.
- o Development of a more precise definition of the spatial extent of measurable free product accumulation in the vicinity of Tank Farm A and in the vicinity of 13GW14.



- o Development of design plans for and implementation of a free product recovery system upon definition of the spatial extent of the liquid phase hydrocarbon plume.

- o Notification of the North Carolina Division of Environmental Management of the findings and results of this investigation.



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TABLES

TABLE 2.1

CONTAMINANT SOURCE INVENTORY*
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SOURCE (Tank No.)	PRODUCT TYPE	INSTALL DATE	SIZE OF TANK (gal.)	TANK STATUS	COMMENTS
1246	Contaminated JP-5	1986	300	P	Removed 3-4 years ago.
----	Contaminated JP-5	1983	1,000	A	Removed and replaced 1990. No # assigned.
TFA-1106	Diesel	1943	26,900	A	
TFA-1107	Gasoline	1943	26,900	A	
TFA-1108	Gasoline	1943	26,900	A	
TFA-1109	Gasoline	1943	26,900	A	
TFA-1110	Diesel	1943	25,000	P	Removed approx. 1982
TFA-1111	Gasoline	1943	25,000	P	Removed approx. 1982
TFA-1112	Diesel	1943	25,000	P	Removed approx. 1982
TFA-1113	Gasoline	1959	210,000	P	Removed approx. 1982
TFA-1191	JP-5	1959	210,000	A	
TFA-1192	JP-5	1961	111,000	A	
TFA-1194	JP-5	1966	105,000	A	
TFA-1248	Diesel	1942	12,000	A	
TFA-1249	Diesel	1942	12,000	A	
TFA-1250	Diesel	1942	12,000	A	
TFA-1251	Diesel	1942	12,000	A	
TFA-1252	Contaminated Fuel	**	4,900	A	
TFA-1253	Contaminated Fuel	**	4,900	A	
4001	JP-5	1982	410,000	A	
4002	JP-5	1982	410,000	A	

Active
 11 USTs
 5 ASTs (exempt)

- A - Active
- P - Passive
- * - Does not include abandoned or active product transmission lines
- ** - Unknown

: Per regs are "field-constructed" and are deferred from total regulations
 except for 1) interim prohibition 2) corrective action requirements



TABLE 2.2

WELL INVENTORY SUMMARY
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

USGS WELL NO.	MCAS WELL NO.	TOTAL WELL DEPTH (FT)	CASING LENGTH (FT)	CASING DIAMETER (INCH)	APPROXIMATE DISTANCE FROM TANK FARM A (FT)	WELL USAGE
31	2	242	228	8	2400	Abandoned
32	1	240	222	8	2000	Abandoned
74	9	299	248	8	2000	Drinking

TABLE 3.1

SUMMARY OF MONITORING WELL DEVELOPMENT
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

MONITORING WELL IDENTIFICATION NUMBER	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (gal)
13GW9	1	90
13GW10	1	95
13GW11	1	100
13GW12	2	100
13GW13	2	105
13GW14	1	80
13GW15	1	90
13GW16	1	95
13GW17	1	90
13GW18	1	95
13GW19	1	90
13GW20	1	100
13GW21	1	80
13GW22	1	90
13GW23	1	90
13GW24	1	90
13GW25	1	100

NOTES:

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

TABLE 4.1 (Page 1 of 5)

SUMMARY OF HEADSPACE ANALYSIS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
13B1	0 - 1.5	Asphalt	
	1.5 - 3.0	4	
	3.0 - 4.5	8	
	8.5 - 10.0	52	*
	13.5 - 15.0	7	
13B2	0 - 1.5	Asphalt	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	70	*
	13.5 - 15.0	8	
13B3	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	100	*
	13.5 - 15.0	80	
13B4	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	90	*
	13.5 - 15.0	40	
13B5	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	2	*
13B6	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	50	
	13.5 - 15.0	60	*

Note:

NS = Not Sampled

TABLE 4.1 (Page 2 of 5)

SUMMARY OF HEADSPACE ANALYSIS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
13B7	0 - 1.5	Asphalt	
	1.5 - 3.0	0	
	3.0 - 4.5	10	*
	8.5 - 10.0	20	
	13.5 - 15.0	5	
13B8	NS		
13B9	0 - 1.5	0	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	*
	13.5 - 15.0	0	
13B10	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	*
	13.5 - 15.0	0	
13GW9	0 - 1.5	Asphalt	
	1.5 - 3.0	30	*
	3.0 - 4.5	20	
	8.5 - 10.0	4	
	13.5 - 15.0	2	
	18.5 - 20.0	5	
13GW10	NS		
13GW11	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	110	*
	13.5 - 15.0	40	

Note:

NS = Not Sampled

TABLE 4.1 (Page 3 of 5)

SUMMARY OF HEADSPACE ANALYSIS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
13GW12	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW13	0 - 1.5	Asphalt	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	*
	13.5 - 15.0	0	
13GW14	0 - 1.5	Asphalt	
	1.5 - 3.0	0	
	3.0 - 4.5	20	
	8.5 - 10.0	70	*
	13.5 - 15.0	60	
13GW15	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW16	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW17	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*

Note:

NS = Not Sampled

TABLE 4.1 (Page 4 of 5)

SUMMARY OF HEADSPACE ANALYSIS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
13GW18	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW19	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW20	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW21	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*
13GW22	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	3	
	13.5 - 15.0	16	*
13GW23	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	30	*
	13.5 - 15.0	20	
13GW24	13.5 - 15.0	0	*

Note:

NS = Not Sampled

TABLE 4.1 (Page 5 of 5)

SUMMARY OF HEADSPACE ANALYSIS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

SAMPLE LOCATION I.D. #	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
13GW25	0 - 1.5	Concrete	
	1.5 - 3.0	0	
	3.0 - 4.5	0	
	8.5 - 10.0	0	
	13.5 - 15.0	0	*

Note:

NS = Not Sampled

TABLE 4.2
SUMMARY OF LABORATORY ANALYTICAL RESULTS
SOIL SAMPLES
REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
TANK FARM A
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6013A

LABORATORY RESULTS

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	TOTAL PETROLEUM HYDROCARBONS (mg/kg)	KEROSENE (mg/kg)*	TOTAL ORGANIC HALIDES (mg/kg)	IGNITABILITY (Degree F)	LEAD (ug/l)
13B1	8.5-10.0	680	1400	6	>200	39
13B2	8.5-10.0	N.D.	130	6	>200	N.D.
13B3	8.5-10.0	N.D.	37000	6	>200	62
13B4	8.5-10.0	N.D.	800	8	>200	50
13B5	13.5-15.0	N.D.		10	>200	37
13B6	13.5-15.0	1055	400	8	>200	43
13B7	3.0- 4.5	N.D.	20	5	>200	N.D.
13B9	8.5-10.0	N.D.		10	>200	N.D.
13B10	8.5-10.0	N.D.		4	>200	N.D.
13GW9	1.5- 3.0	N.D.		9	>200	N.D.
13GW11	8.5-10.0	N.D.	22000	19	>200	N.D.
13GW12	13.5-15.0	N.D.		33	>200	N.D.
13GW13	13.5-15.0	N.D.		9	>200	N.D.
13GW14	8.5-10.0	1000	1500	35	>200	65
13GW15	13.5-15.0	N.D.		44	>200	N.D.
13GW16	13.5-15.0	N.D.		24	>200	N.D.
13GW17	13.5-15.0	N.D.		18	>200	N.D.
13GW18	13.5-15.0	N.D.		42	>200	N.D.
13GW19	1.5- 3.0	N.D.		12	>200	N.D.
13GW20	13.5-15.0	N.D.		70	>200	N.D.
13GW21	13.5-15.0	N.D.		N.D.	>200	N.D.
13GW22	13.5-15.0	N.D.		81	>200	N.D.
13GW23	8.5-10.0	N.D.	660	34	>200	28
13GW24	13.5-15.0	N.D.		35	>200	N.D.
13GW25	13.5-15.0	N.D.		60	>200	N.D.

NOTES:

N.D. = Not Detected; see laboratory reports for applicable detection limits.
* Kerosene qualitatively identified only.

TABLE 4.3 (Page 1 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
 GROUND WATER SAMPLES
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

PARAMETER	WELL # : DATE SAMPLED:	13GW1 11/8/90	13GW2 11/8/90	13GW3 11/8/90	13GW4 11/8/90	13GW5 11/7/90	13GW6 11/7/90	13GW7 11/7/90	13GW8 11/8/90	13GW9 11/7/90	13GW10 11/6/90	13GW11 11/6/90	13GW12 11/7/90	13GW13 11/8/90	13GW14 11/7/90
Acenaphthylene		-	6	-	-	-	-	-	-	-	-	-	-	-	-
Benzene		270	900	N.D.	N.D.	N.D.	25	N.D.	N.D.	190	42	2	0.4	N.D.	3500
Chlorobenzene		720	N.D.	N.D.	N.D.	N.D.	N.D.								
Chloroform		N.D.	3	N.D.	N.D.	N.D.									
Ethylbenzene		3900	200	280	580	N.D.	77	N.D.	N.D.	210	110	N.D.	N.D.	N.D.	1850
Fluorene		-	4	-	-	-	-	-	-	-	-	-	-	-	-
Lead		65	376	91	49	244	117	7	13	47	47	2	71	21	3200
Methylene Chloride		N.D.	N.D.	N.D.	N.D.	3	296	5	N.D.	310	N.D.	N.D.	N.D.	13	6000
Methylene Chloride (Lab Blank)						3	160	3	3.6	64				10	800
Naphthalene		-	43	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene		-	0.4	-	-	-	-	-	-	-	-	-	-	-	-
Trichlorethene		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1	8	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Toluene		N.D.	N.D.	N.D.	N.D.	0.3	320	N.D.	N.D.	175	100	N.D.	0.3	0.7	8300
Xylenes (total)		4400	550	960	2300	0.9	340	N.D.	N.D.	N.D.	450	0.8	1	N.D.	7300

NOTES:

-
- * All results are ug/l.
 - N.D. = Not Detected; see laboratory reports for applicable detection limits.
 - = Sample not analyzed for this parameter.
 - ** NC ground-water standard = detection limit



TABLE 4.3 (Page 2 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
GROUND-WATER SAMPLES
REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
TANK FARM A
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6013A

PARAMETER	WELL # DATE SAMPLED:	13GW15 11/7/90	13GW16 11/7/90	13GW17 11/7/90	13GW18 11/7/90	13GW19 11/7/90	13GW20 11/7/90	13GW21 11/7/90	13GW22 11/7/90	13GW23 11/7/90	13GW24 11/7/90	13GW25 11/7/90
Acenaphthylene		-	-	-	-	-	-	-	-	-	-	-
Benzene		N.D.	N.D.	2	N.D.	0.9	N.D.	N.D.	620	0.6	54	4
Chlorobenzene		N.D.										
Chloroform		N.D.	2	N.D.	N.D.							
Ethylbenzene		N.D.	0.9	1	N.D.							
Fluorene		-	-	-	-	-	-	-	-	-	-	-
Lead		34	38	45	168	64	24	38	39	152	56	39
Methylene Chloride		N.D.	N.D.	N.D.	5	N.D.	N.D.	N.D.	N.D.	N.D.	14	N.D.
Methylene Chloride (Lab Blank)					3						3	
Naphthalene		-	-	-	-	-	-	-	-	-	-	-
Phenanthrene		-	-	-	-	-	-	-	-	-	-	-
Trichlorethene		N.D.	N.D.	N.D.	N.D.	1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Toluene		N.D.	N.D.	0.4	N.D.	N.D.	N.D.	N.D.	N.D.	0.8	2	N.D.
Xylenes (total)		0.7	0.7	3	0.8	0.8	N.D.	0.9	260	4	5	2

NOTES:

- * All results are ug/l.
N.D. = Not Detected; see laboratory reports for applicable detection limits.
- = Sample not analyzed for this parameter.

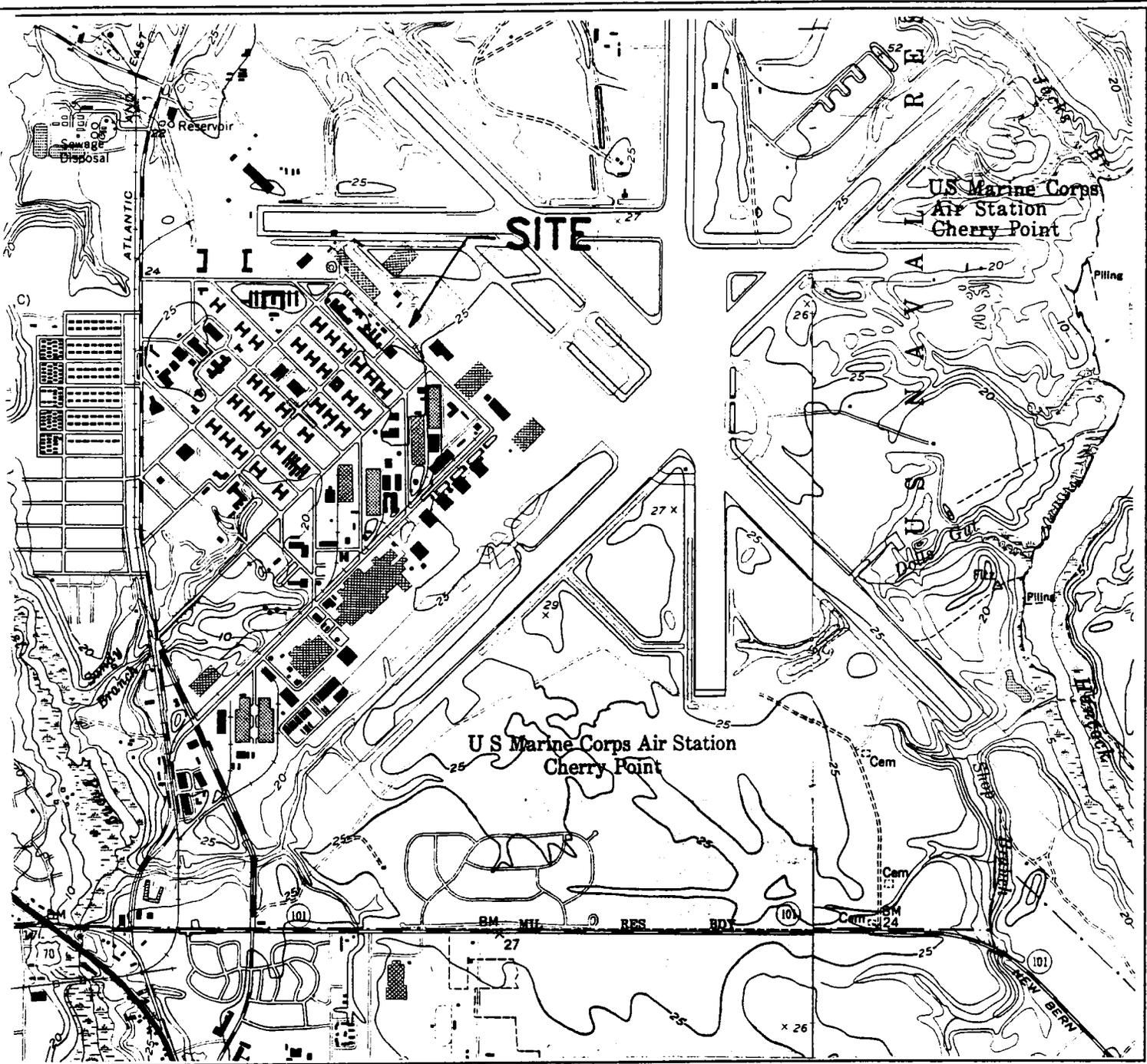
TABLE 6.1

SUMMARY OF EXPOSURE PATHWAYS
 REPORT OF UNDERGROUND FUEL INVESTIGATION
 COMPREHENSIVE SITE ASSESSMENT
 TANK FARM A
 MARINE CORPS AIR STATION
 CHERRY POINT, NORTH CAROLINA
 LAW ENGINEERING JOB NO. J47590-6013A

CONTAMINATED MEDIUM	INGESTION (EATING)	INGESTION (DRINKING)	INHALATION	ABSORPTION
Free Product	NA	No Exposure (1)	NA	No Exposure (1)
Soil	Contingent Exposure (2)	NA	NA	Contingent Exposure (2)
Ground Water	Exposure Unlikely (3)	Exposure Unlikely (3)	NA	Exposure Unlikely (3)
Surface Water	No Exposure (4)	No Exposure (4)	NA	No Exposure (4)
Vapor	NA	NA	Possible Exposure (5)	NA

Notes:

-
- (1) No free product detected in surface waters; water supply wells draw from Castle Hayne aquifer.
 - (2) Potential for exposure only if subsurface below 8 feet BLS is disturbed.
 - (3) Via use of MCAS water supply wells for drinking, cooking, and bathing; however, no indication of contaminants in nearby wells based on 1988 USGS sampling results.
 - (4) Ground-water sampling results indicate that plume does not extend to surface waters.
 - (5) Potential for exposure during maintenance/repair work in subsurface utility confinements particularly in areas exhibiting presence of free product.



NORTH

HAVELOCK, N. C. CHERRY POINT, N. C.

34076-H8-TF-024

34076-H7-TF-024



QUADRANGLE LOCATION



QUADRANGLE LOCATION

1949

PHOTOREVISED 1983

DMA 5853 IV NW-SERIES V842

1949

PHOTOREVISED 1983

DMA 5853 IV NE-SERIES V842

NOTE: ALL LOCATIONS ARE APPROXIMATE.

CONTOUR INTERVAL 5 FEET

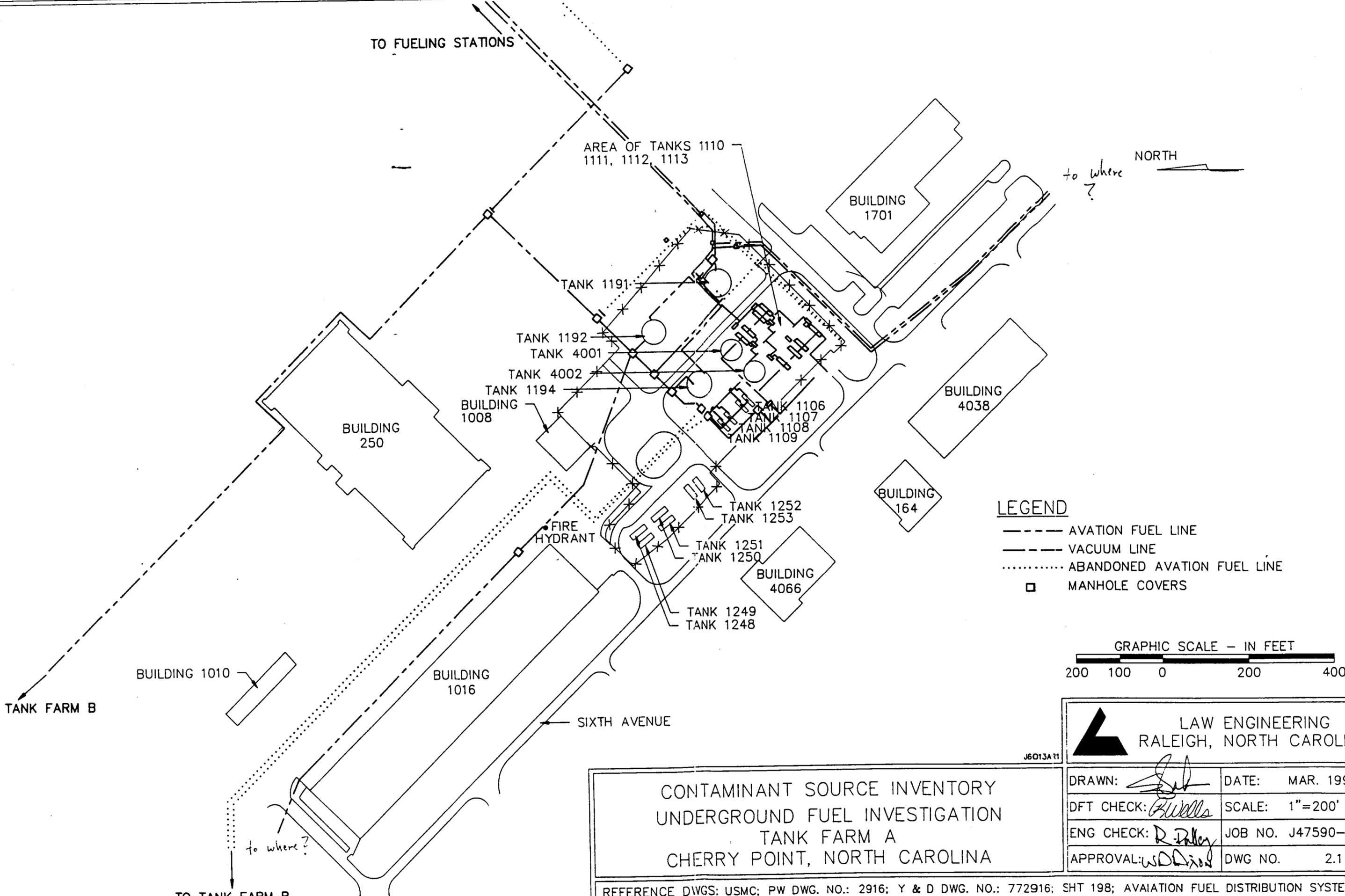
GRAPHIC SCALE FEET



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GENERAL LOCATION
UNDERGROUND FUEL INVESTIGATION
TANK FARM A
CHERRY POINT, NORTH CAROLINA

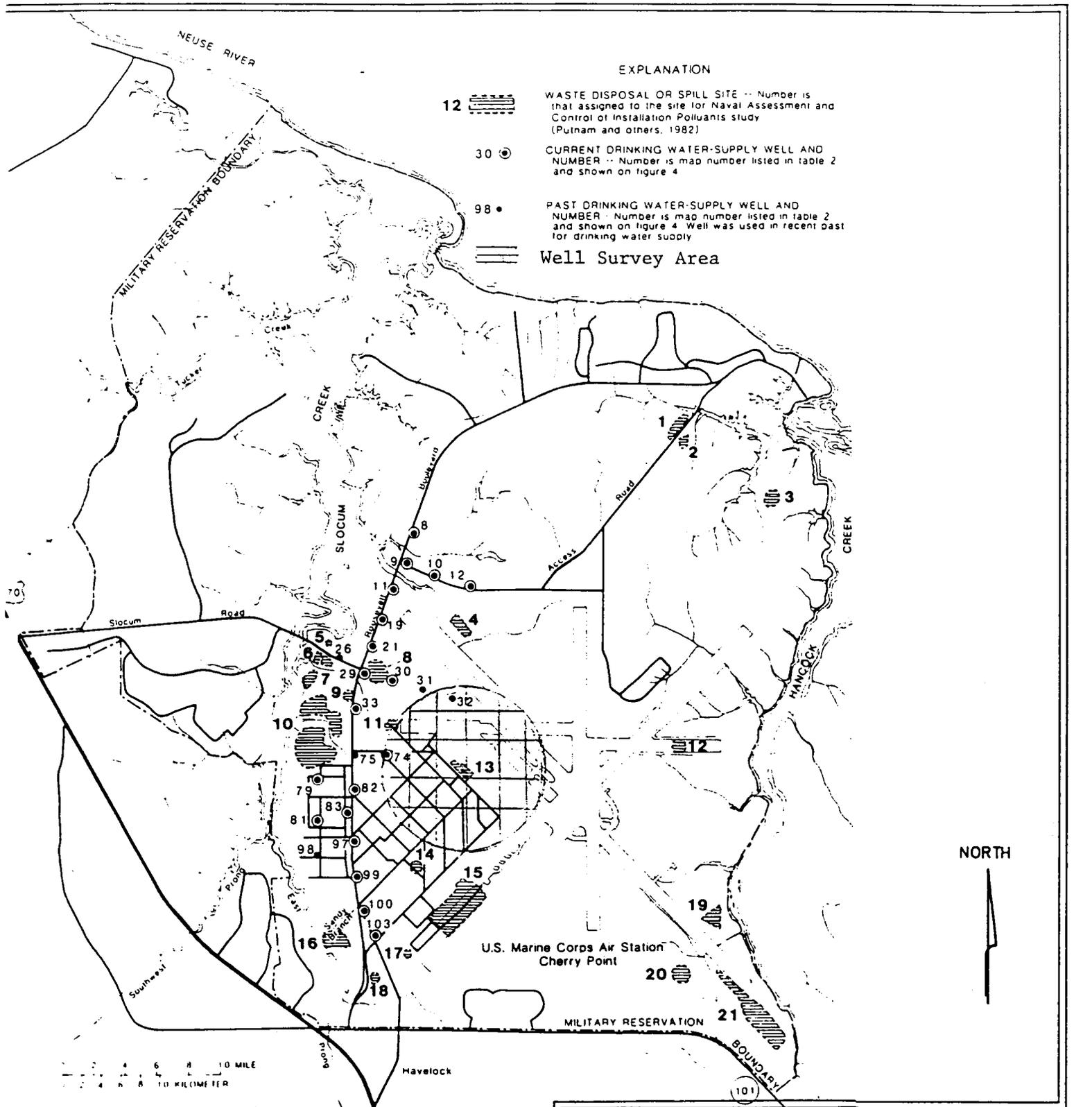
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APPROVAL: <i>[Signature]</i>	DWG NO. 1.1



CONTAMINANT SOURCE INVENTORY
UNDERGROUND FUEL INVESTIGATION
TANK FARM A
CHERRY POINT, NORTH CAROLINA

 LAW ENGINEERING RALEIGH, NORTH CAROLINA	
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 2.1

REFERENCE DWGS: USMC; PW DWG. NO.: 2916; Y & D DWG. NO.: 772916; SHT 198; AVAIIATION FUEL DISTRIBUTION SYSTEM



EXPLANATION

- 12 WASTE DISPOSAL OR SPILL SITE -- Number is that assigned to the site for Naval Assessment and Control of Installation Pollutants study (Putnam and others, 1982)
- 30 CURRENT DRINKING WATER-SUPPLY WELL AND NUMBER -- Number is map number listed in table 2 and shown on figure 4
- 98 • PAST DRINKING WATER-SUPPLY WELL AND NUMBER -- Number is map number listed in table 2 and shown on figure 4 Well was used in recent past for drinking water supply
- Well Survey Area

NORTH

0 2 4 6 8 10 MILE
0 2 4 6 8 10 KILOMETER

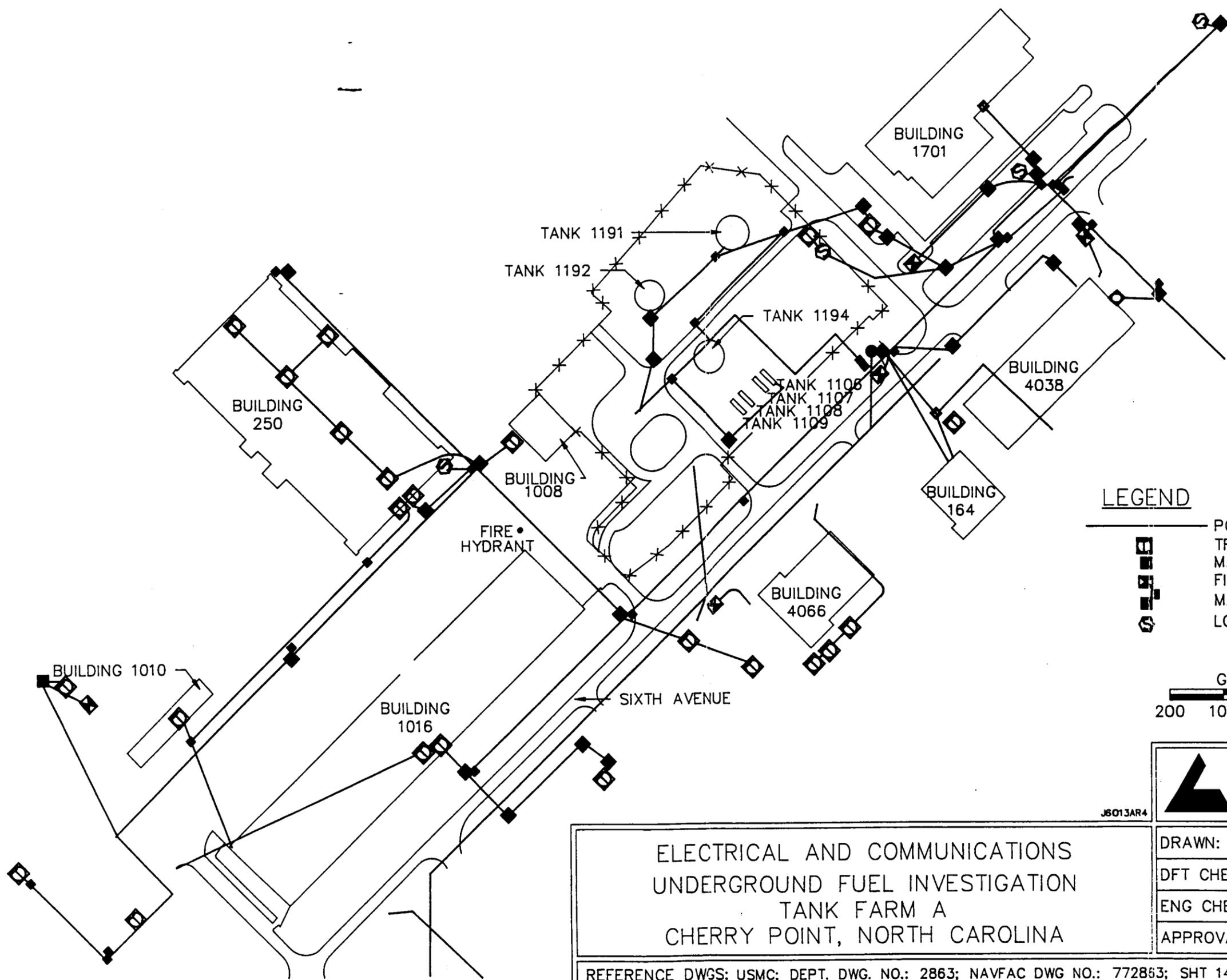
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6013AR16

WELL SURVEY AREA
UNDERGROUND FUEL INVESTIGATION
TANK FARM A
CHERRY POINT, NORTH CAROLINA

DRAWN:	DATE: DEC. 1990
DFT CHECK:	SCALE: NOTED
ENG CHECK:	JOB NO. J47590-6013A
APPROVAL:	DWG NO. 2.2

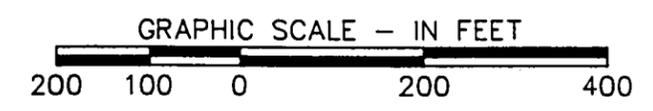
REFERENCE DWGS: U.S.D.I.; WATER RESOURCES INVESTIGATION REPORT 88-4034



NORTH

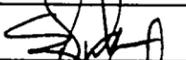
LEGEND

-  POWER AND/OR COMMUNICATION LINE
-  TRANSFORMER SUBSTATION
-  MANHOLE
-  FIRE ALARM STATION
-  MANHOLE, POWER AND SIGNAL SECTION
-  LOAD BREAK OIL, SW

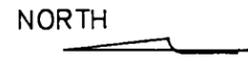
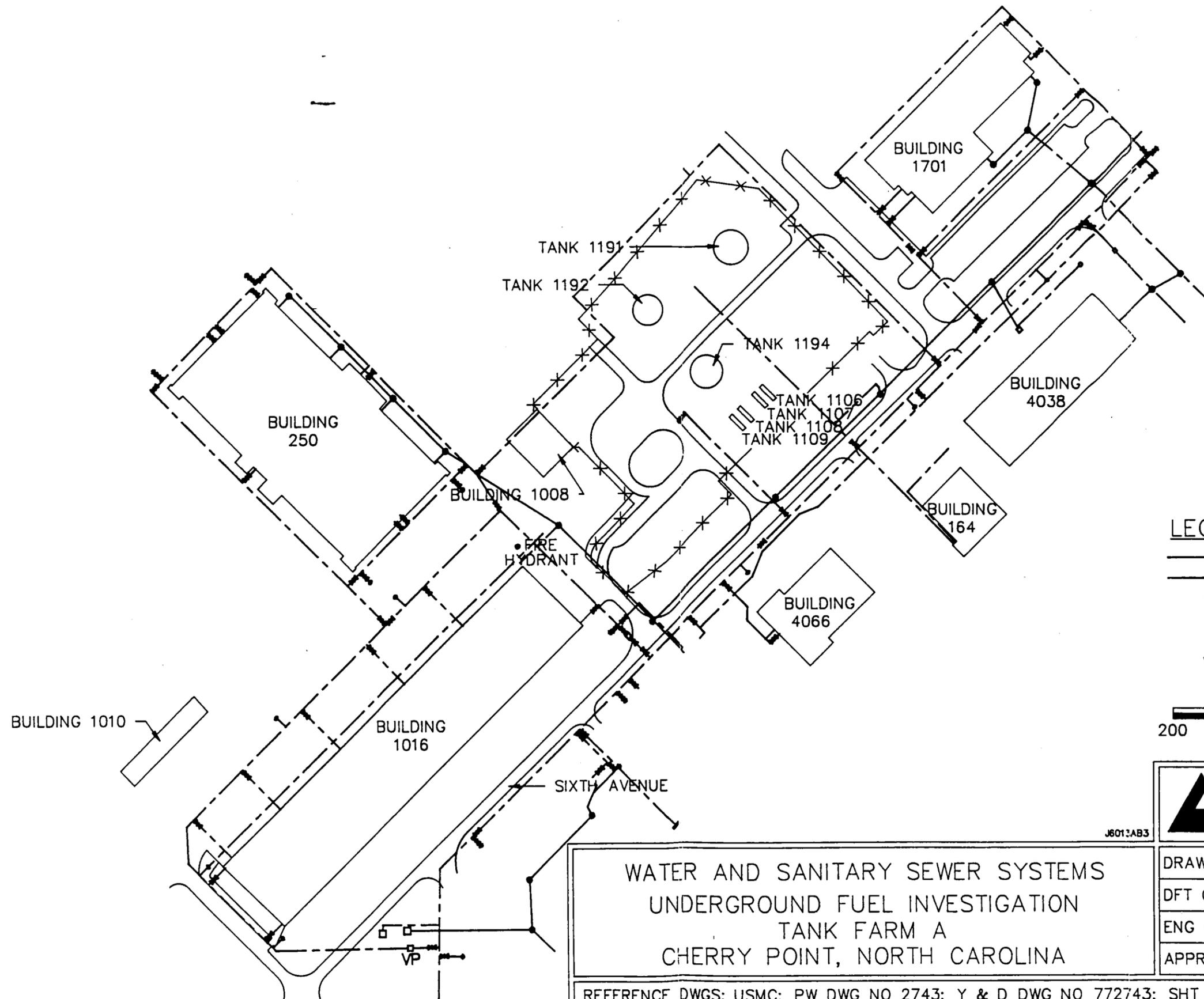


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ELECTRICAL AND COMMUNICATIONS
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: 	DATE: DEC. 1990
DFT CHECK: 	SCALE: 1"=200'
ENG CHECK: 	JOB NO. J47590-6013A
APPROVAL: 	DWG NO. 2.3

REFERENCE DWGS: USMC; DEPT. DWG. NO.: 2863; NAVFAC DWG NO.: 772853; SHT 145; ELECTRICAL AND COMMUNICATIONS



LEGEND

- SANITARY SEWER
- - - FRESH WATER MAIN
- VALVE
- MANHOLE
- PIT
- VP VALVE PIT

GRAPHIC SCALE - IN FEET

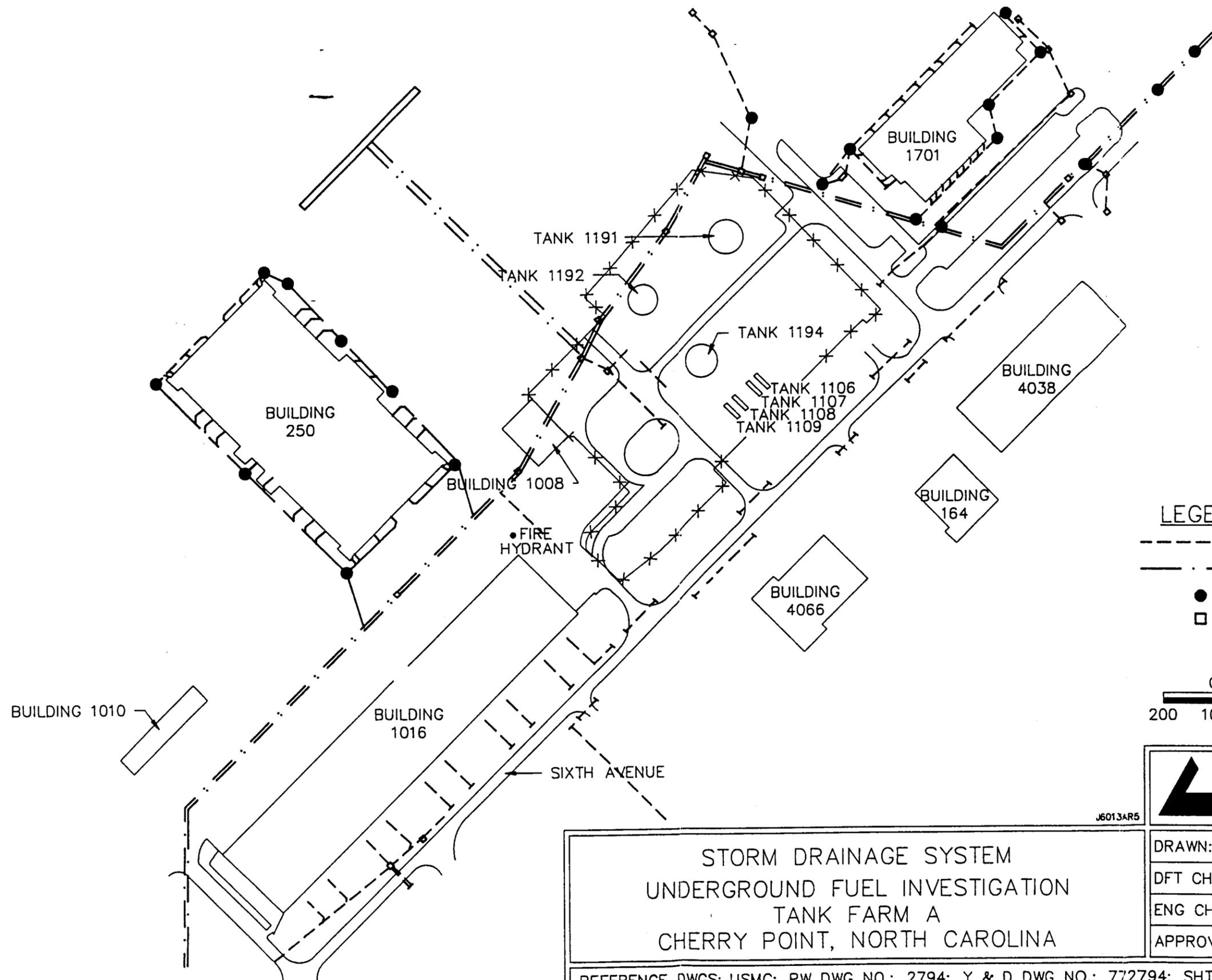
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WATER AND SANITARY SEWER SYSTEMS
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>[Signature]</i>	DATE: DEC. 1990
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 2.4

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



NORTH

LEGEND

- STORM SEWER PIPE LOCATION
- - - STORM SEWER BOX CULVERT
- MANHOLE
- CATCH BASIN

GRAPHIC SCALE - IN FEET

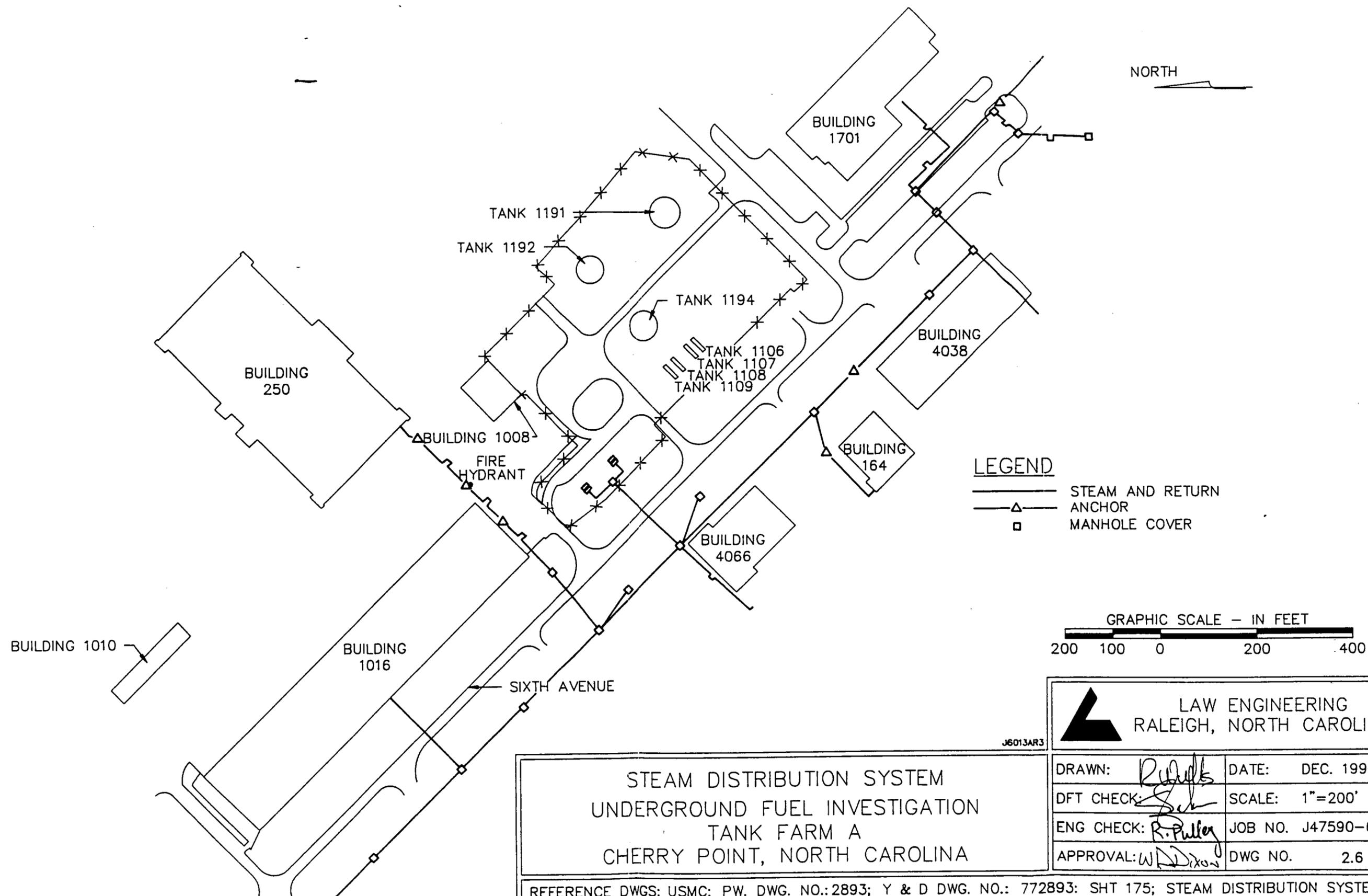


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STORM DRAINAGE SYSTEM
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>R. Wells</i>	DATE: DEC. 1990
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>R. Pulley</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 2.5.

REFERENCE DWGS: USMC; PW DWG NO.: 2794; Y & D DWG NO.: 772794; SHT 76; STORM DRAINAGE SYSTEM



LEGEND

- STEAM AND RETURN
- △— ANCHOR
- MANHOLE COVER



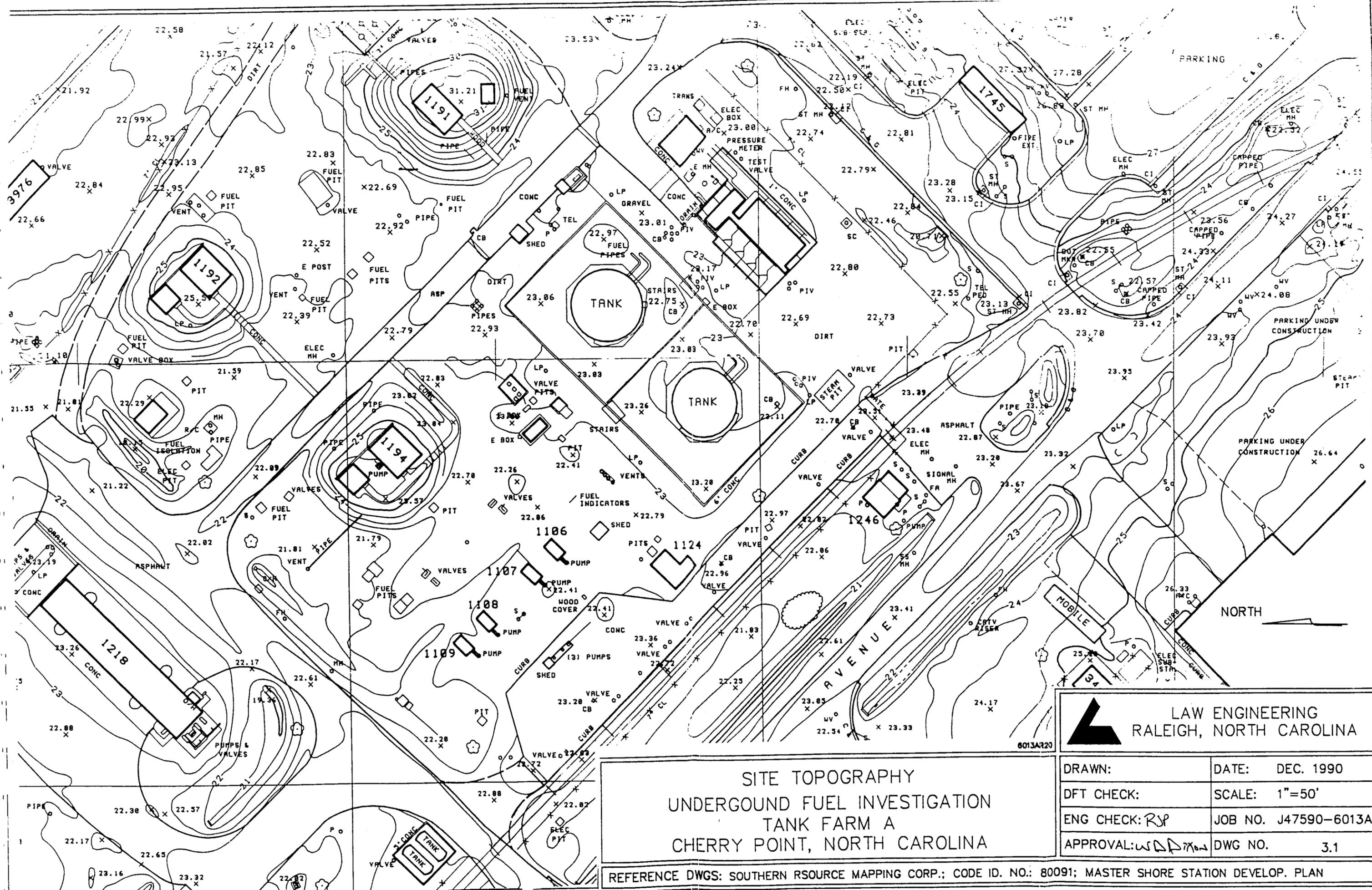
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J6013AR3

STEAM DISTRIBUTION SYSTEM
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>R. Puller</i>	DATE: DEC. 1990
DFT CHECK: <i>Sch</i>	SCALE: 1"=200'
ENG CHECK: <i>R. Puller</i>	JOB NO. J47590-6013A
APPROVAL: <i>W. Dixon</i>	DWG NO. 2.6

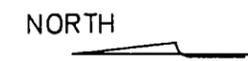
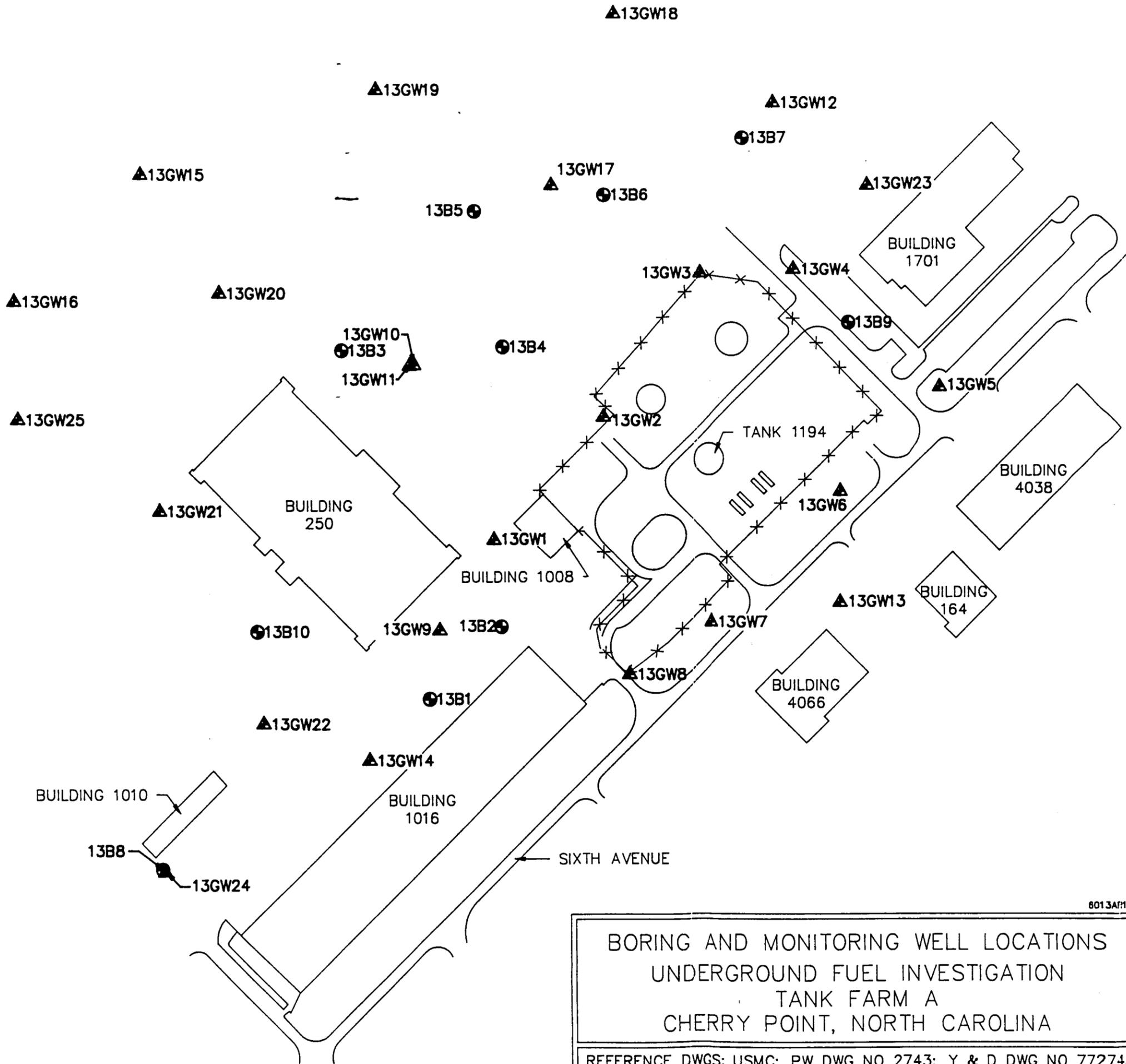
REFERENCE DWGS: USMC; PW. DWG. NO.: 2893; Y & D DWG. NO.: 772893; SHT 175; STEAM DISTRIBUTION SYSTEM



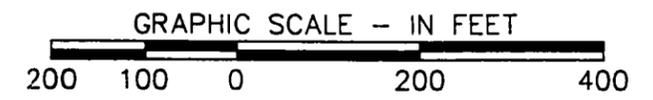
SITE TOPOGRAPHY
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

 LAW ENGINEERING RALEIGH, NORTH CAROLINA	
DRAWN:	DATE: DEC. 1990
DFT CHECK:	SCALE: 1"=50'
ENG CHECK: RSP	JOB NO. J47590-6013A
APPROVAL: WAD	DWG NO. 3.1

REFERENCE DWGS: SOUTHERN RSOURCE MAPPING CORP.; CODE ID. NO.: 80091; MASTER SHORE STATION DEVELOP. PLAN



- LEGEND**
- 13B1 BORING LOCATION
 - ▲ 13GW1 MONITORING WELL LOCATION

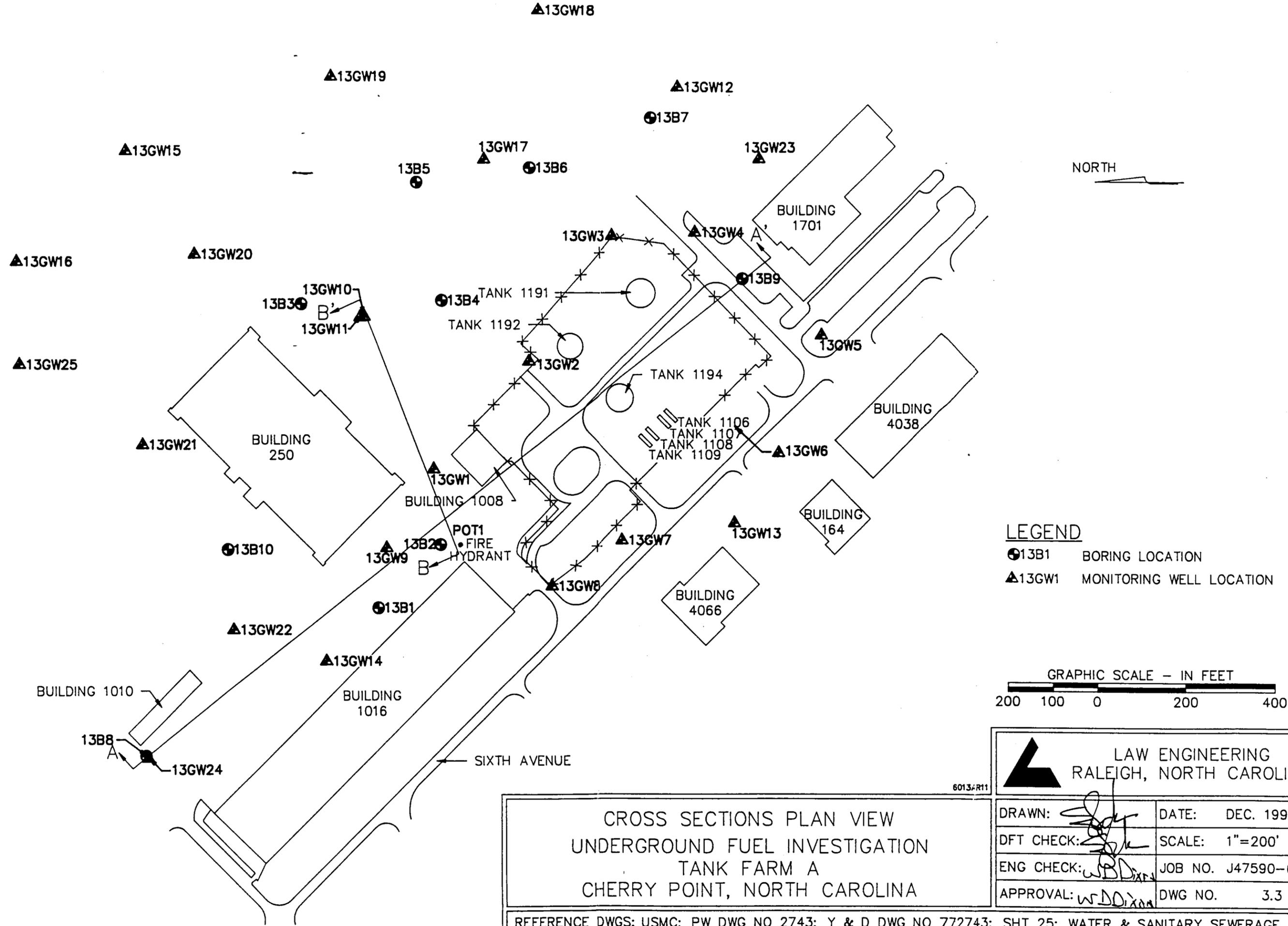


 LAW ENGINEERING RALEIGH, NORTH CAROLINA	
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 3.2

BORING AND MONITORING WELL LOCATIONS
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.

6013A/10

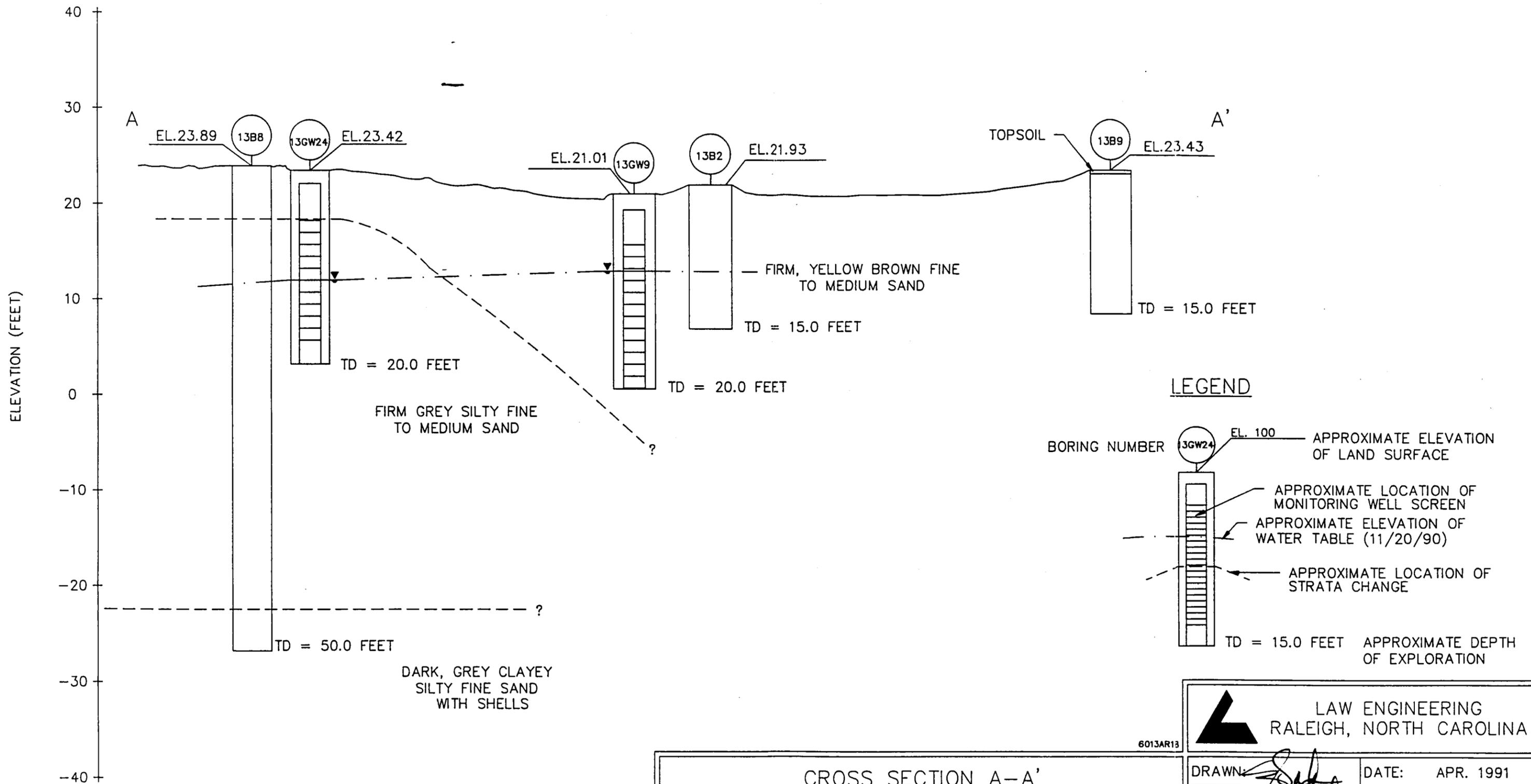


CROSS SECTIONS PLAN VIEW
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

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DRAWN: <i>[Signature]</i>	DATE: DEC. 1990
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
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APPROVAL: <i>[Signature]</i>	DWG NO. 3.3

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.

6013/R11



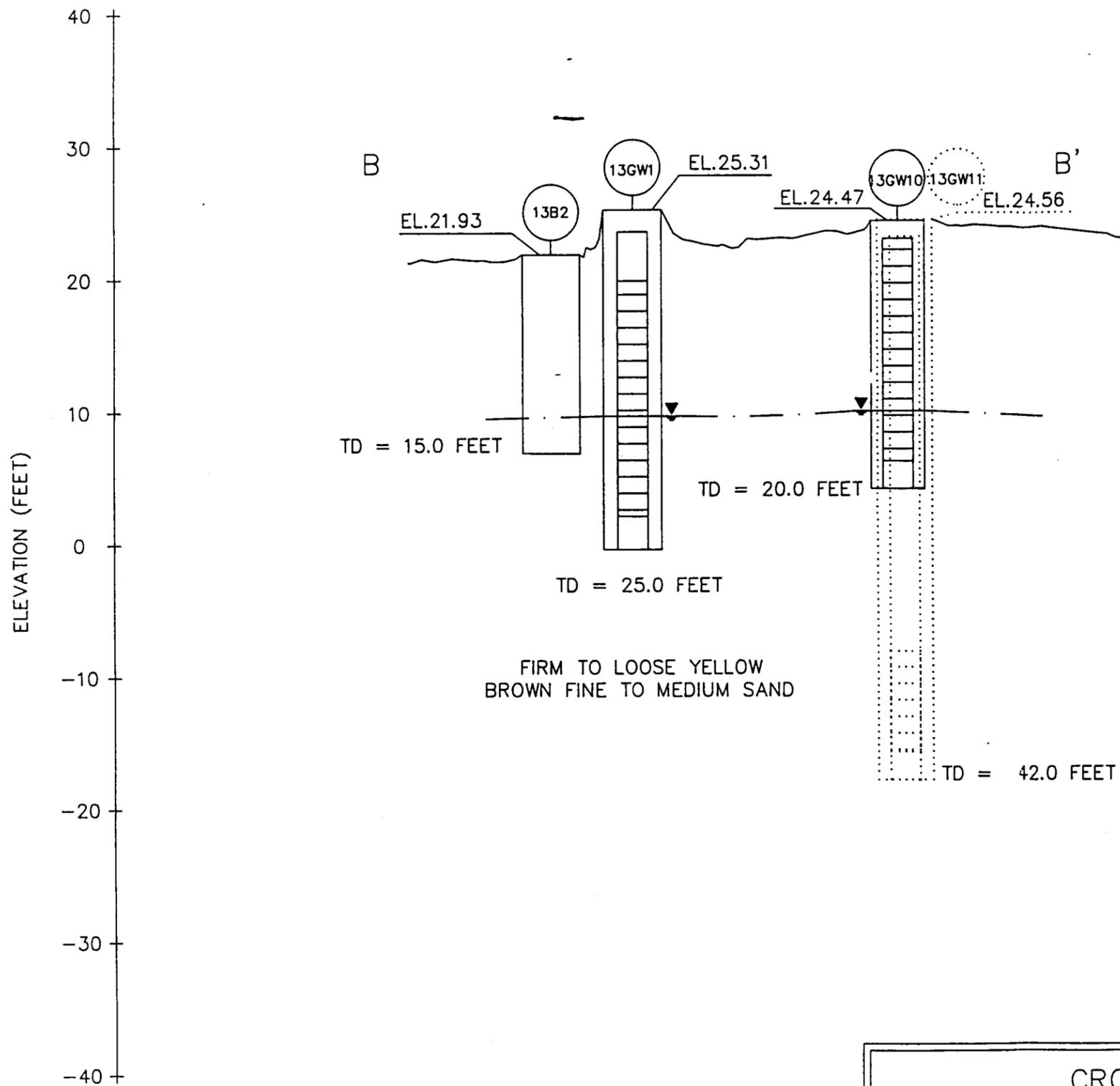
CROSS SECTION A-A'
CHERRY POINT MARINE AIR STATION
TANK FARM A
CHERRY POINT, NORTH CAROLINA

REFERENCE DWGS:

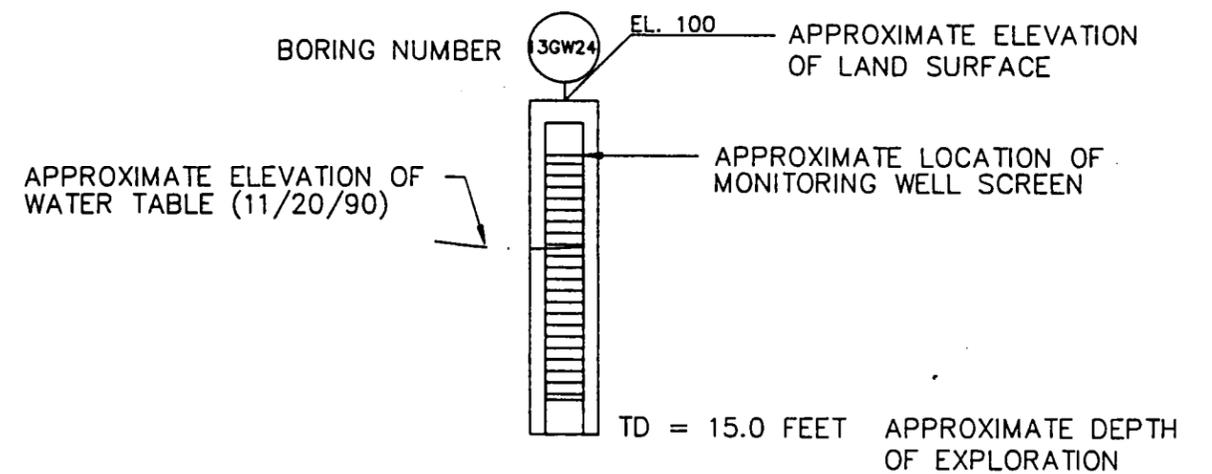

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DRAWN: <i>[Signature]</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1" = 10' VERT. 1" = 200' HOR.
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 3.4

6013AR13



LEGEND



NOTE: 13GW11 IS ACTUALLY LOCATED ADJACENT TO 13GW10. THE HORIZONTAL DISTANCE SHOWN BETWEEN THESE WELLS ON THIS DRAWING IS NOT TO SCALE.

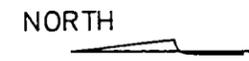
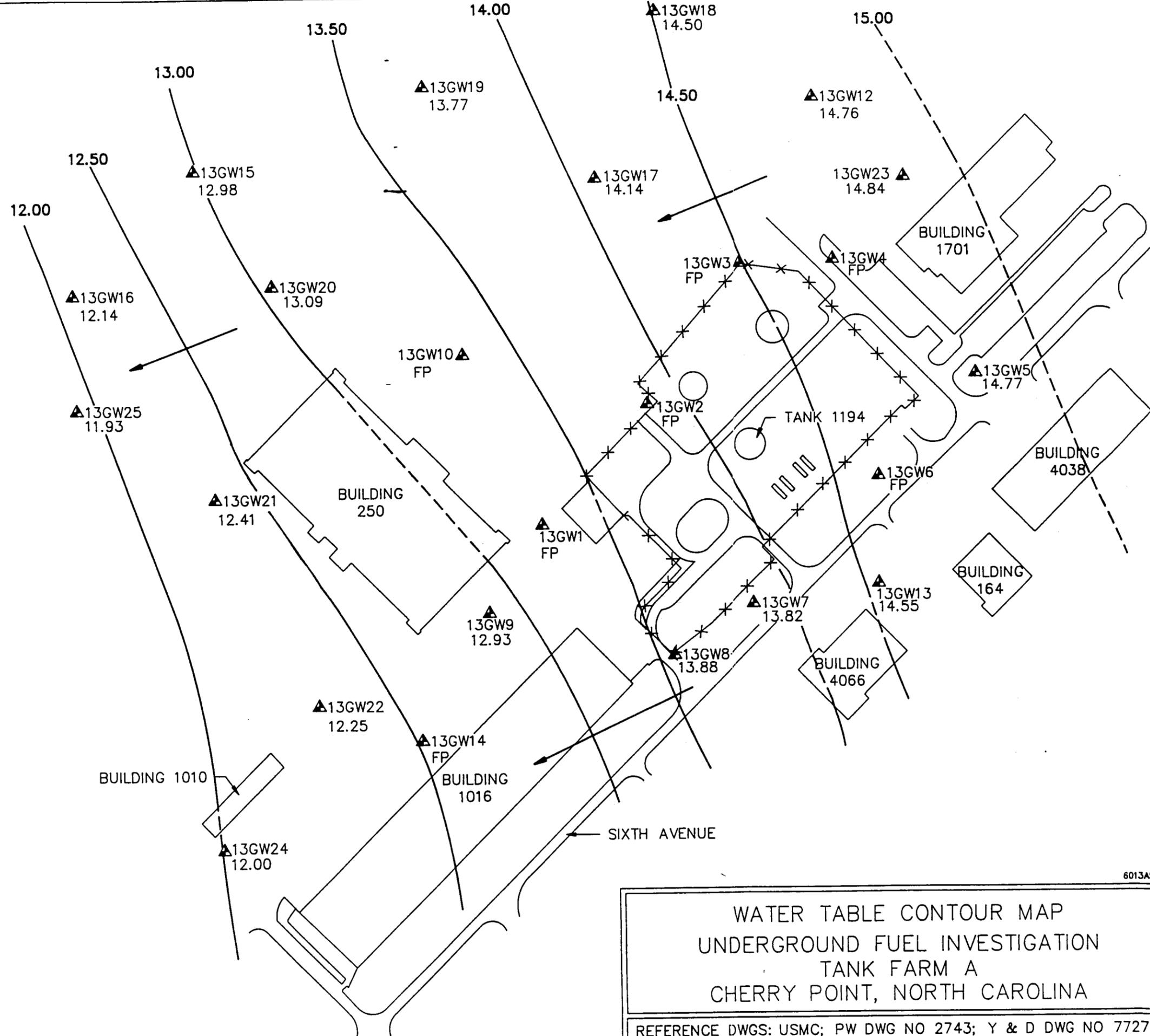
6013AR17


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CROSS SECTION B-B'
 CHERRY POINT MARINE AIR STATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

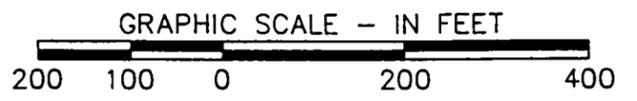
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ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 3.5

REFERENCE DWGS:



LEGEND

- ← APPROXIMATE DIRECTION OF GROUND-WATER FLOW IN THE WATER TABLE AQUIFER
- 90.00 — ESTIMATED WATER TABLE ELEVATION ISOPLETH
- ▲13GW1 MONITORING WELL LOCATION
- 91.00 MEASURED GROUND-WATER ELEVATION (11/20/90)
- FP FREE PRODUCT PRESENT IN MONITORING WELL

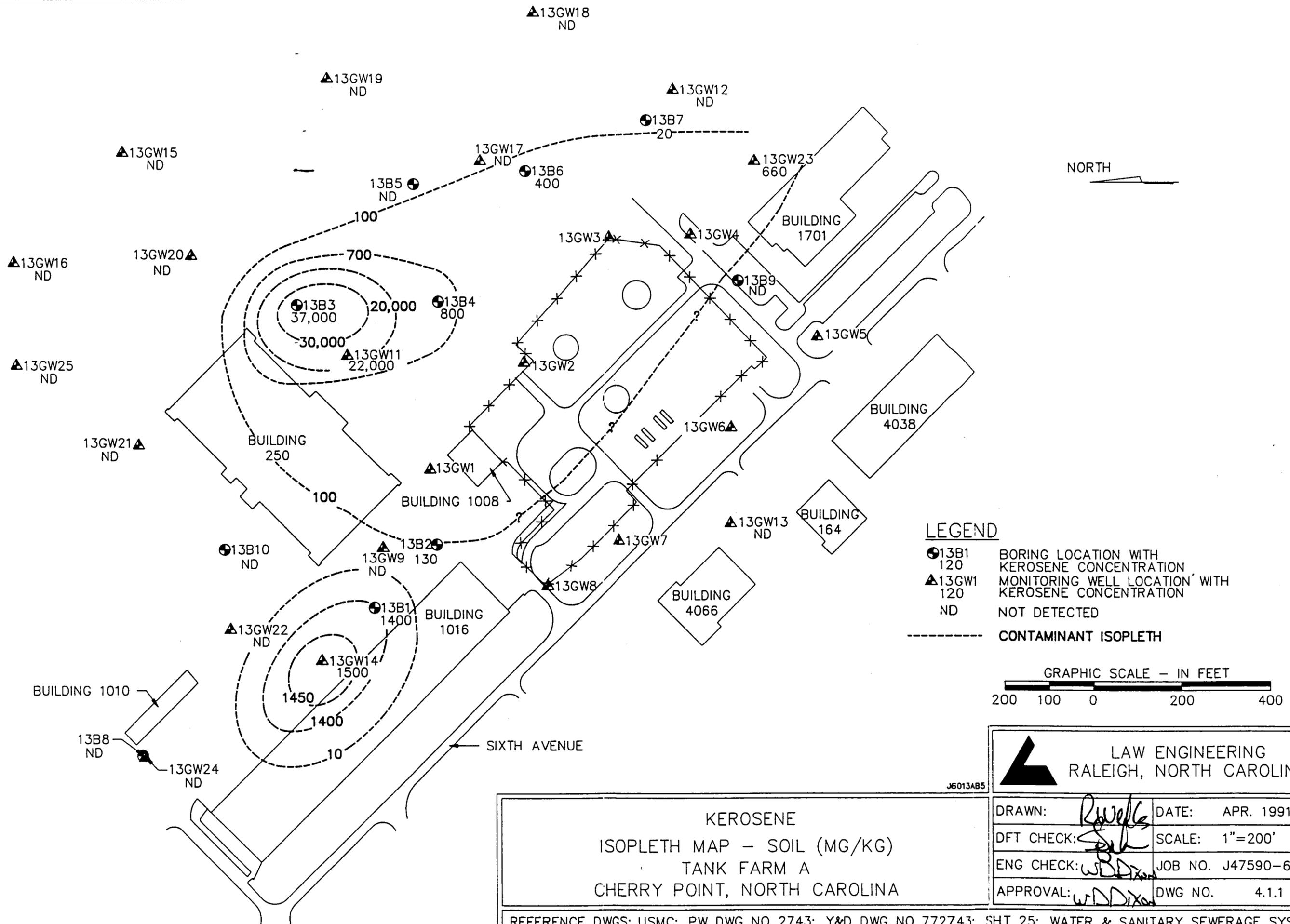


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WATER TABLE CONTOUR MAP
 UNDERGROUND FUEL INVESTIGATION
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>R. Williams</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 3.6

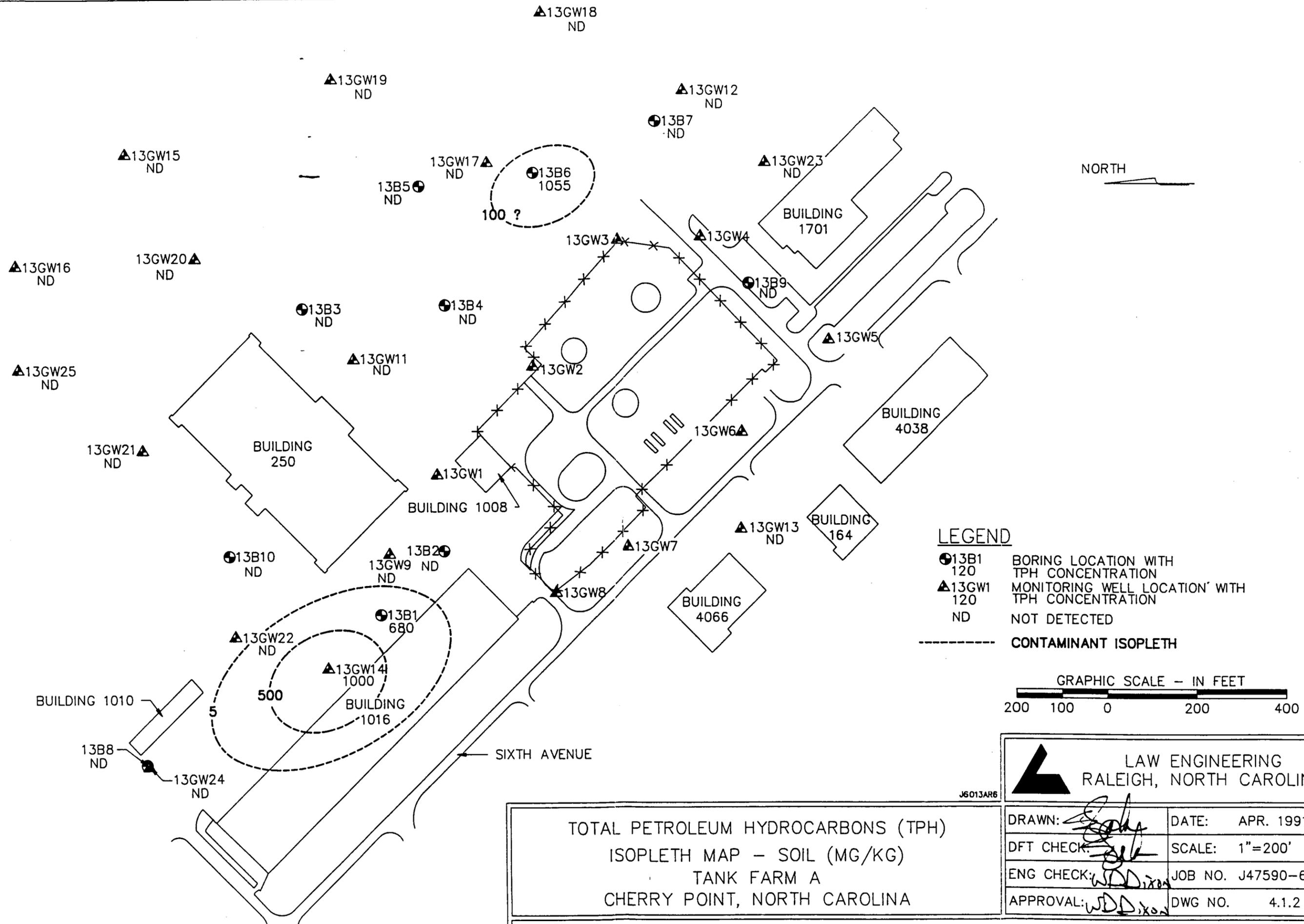
REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



KEROSENE
 ISOPLETH MAP - SOIL (MG/KG)
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

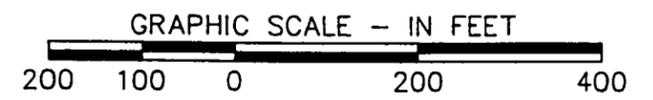
 LAW ENGINEERING RALEIGH, NORTH CAROLINA	
DRAWN: <i>R. Wells</i>	DATE: APR. 1991
DFT CHECK: <i>S. H.</i>	SCALE: 1"=200'
ENG CHECK: <i>W.D. Dixon</i>	JOB NO. J47590-6013A
APPROVAL: <i>W.D. Dixon</i>	DWG NO. 4.1.1

REFERENCE DWGS: USMC; PW DWG NO 2743; Y&D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



LEGEND

- 13B1 120 BORING LOCATION WITH TPH CONCENTRATION
- ▲ 13GW1 120 MONITORING WELL LOCATION WITH TPH CONCENTRATION
- ND NOT DETECTED
- CONTAMINANT ISOPLETH



LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOTAL PETROLEUM HYDROCARBONS (TPH)
 ISOPLETH MAP - SOIL (MG/KG)
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>[Signature]</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.1.2

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743. SHT 25; WATER & SANITARY SEWERAGE SYS.

▲13GW18

▲13GW19

▲13GW12

▲13GW15

▲13GW17

▲13GW23

NORTH

●13B7

●13B6

●13B5

BUILDING 1701

▲13GW16

▲13GW20

▲13GW3
0.2

▲13GW4
1.1

▲13GW10
1.6

●13B3

●13B4

●13B9

▲13GW25

▲13GW11

▲13GW2
1.7

TANK 1194

▲13GW5

BUILDING 4038

▲13GW21

BUILDING 250

▲13GW1
1.7

▲13GW6
0.4

BUILDING 1008

▲13GW13

BUILDING 164

●13B10

▲13GW9

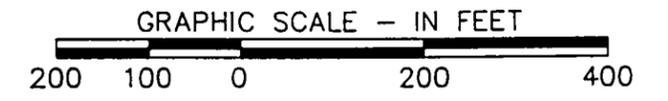
●13B2

▲13GW7

BUILDING 4066

LEGEND

- 13B1 BORING LOCATION
- ▲13GW1 MONITORING WELL LOCATION
- 2.0 ESTIMATED FREE PRODUCT THICKNESS
- FREE PRODUCT THICKNESS ISOPLETH



BUILDING 1010

▲13GW22

●13B1

▲13GW14
1.3

BUILDING 1016

SIXTH AVENUE

13B8

13GW24

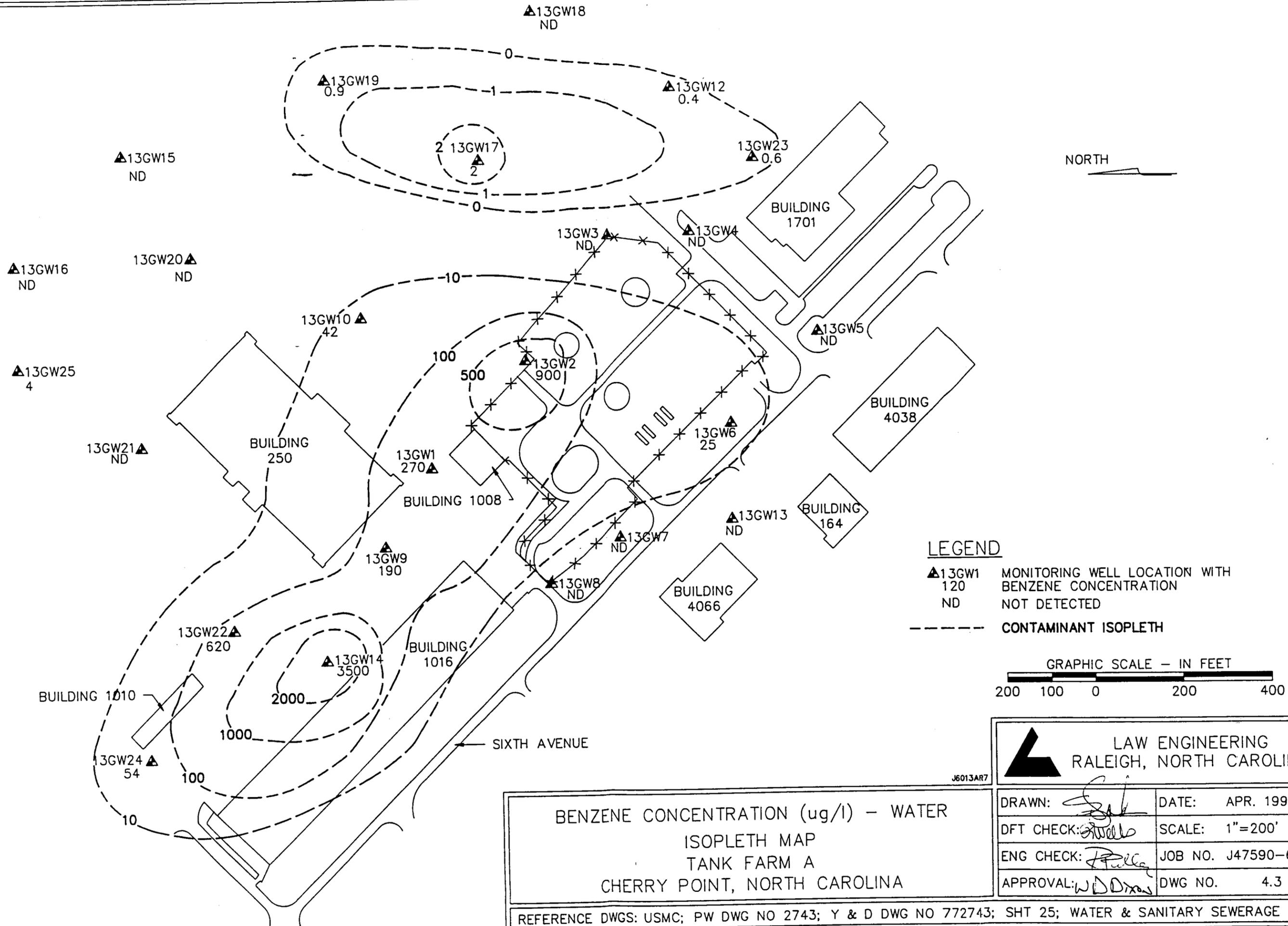
J6013AB4

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ESTIMATED SPATIAL EXTENT OF FREE PRODUCT
UNDERGROUND FUEL INVESTIGATION
TANK FARM A
CHERRY POINT, NORTH CAROLINA

DRAWN: <i>R. [Signature]</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>W.D. Dixon</i>	JOB NO. J47590-6013A
APPROVAL: <i>W.D. Dixon</i>	DWG NO. 4.2

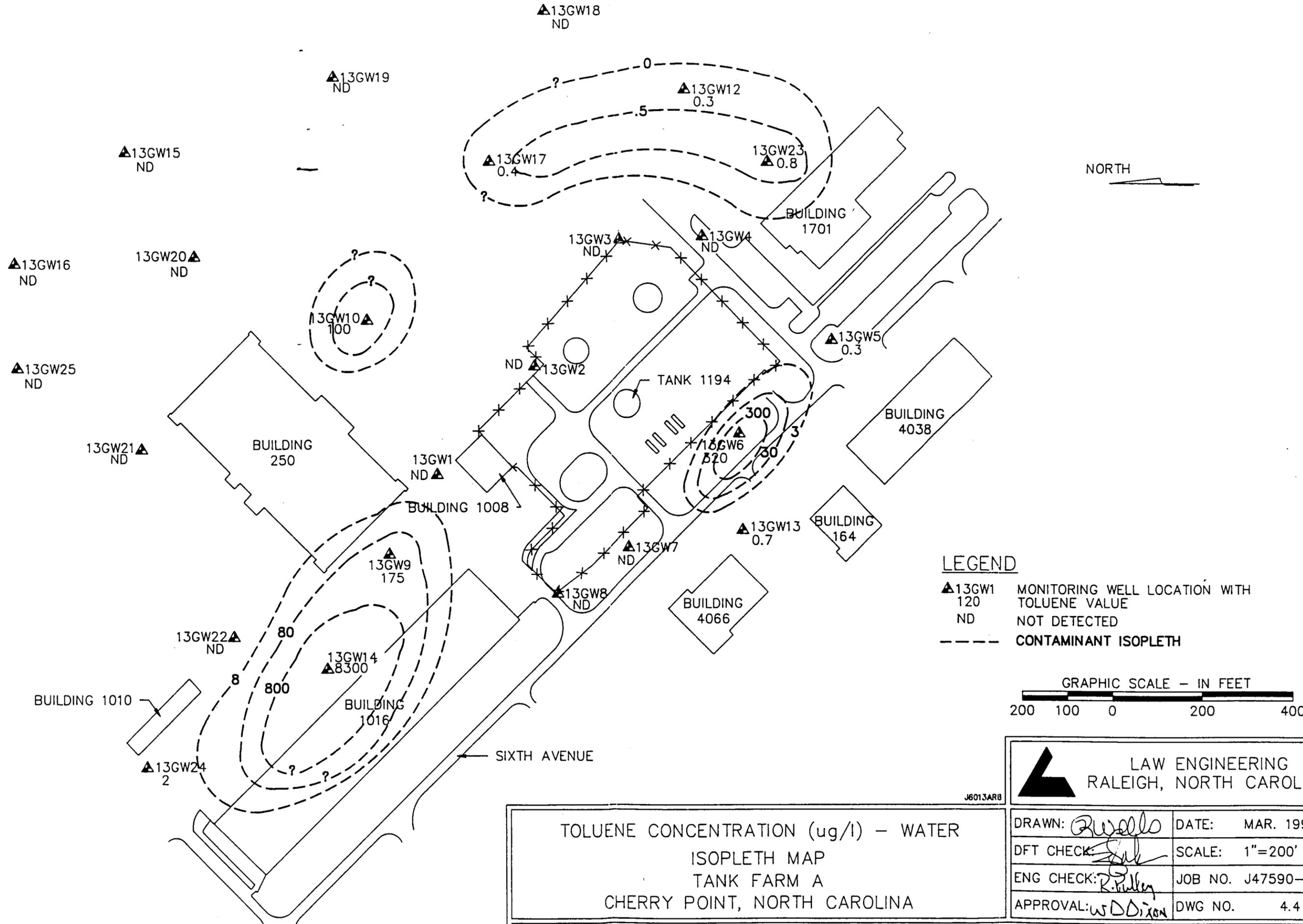
REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



BENZENE CONCENTRATION (ug/l) - WATER
 ISOPLETH MAP
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

LAW ENGINEERING RALEIGH, NORTH CAROLINA	
DRAWN: <i>[Signature]</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.3

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.

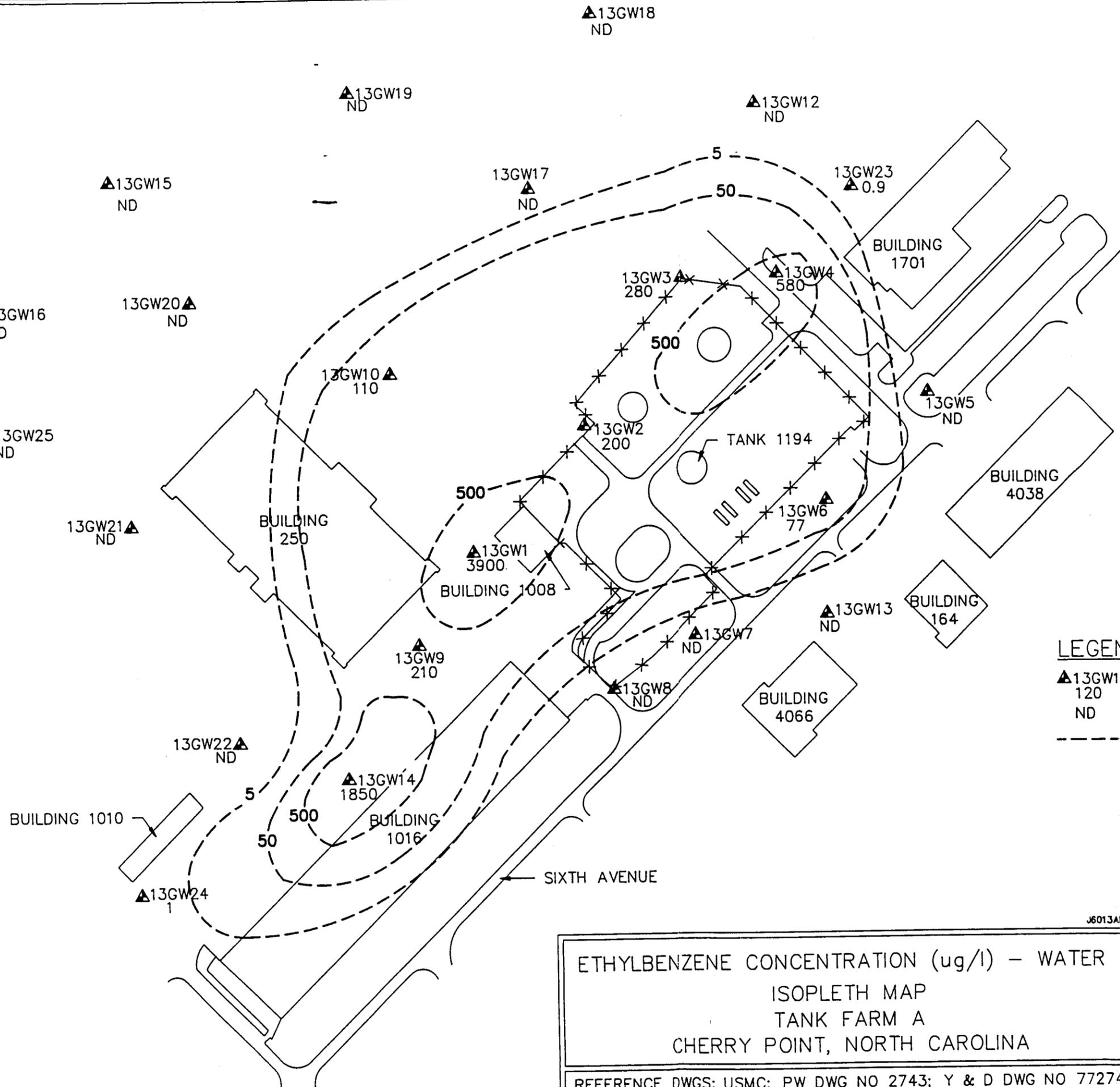


TOLUENE CONCENTRATION (ug/l) - WATER
 ISOPLETH MAP
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

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 RALEIGH, NORTH CAROLINA

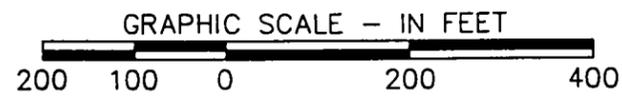
DRAWN: <i>R. Wells</i>	DATE: MAR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>R. Miller</i>	JOB NO. J47590-6013A
APPROVAL: <i>W.D. Dixon</i>	DWG NO. 4.4

REFERENCE DWGS: USMC; PW DDWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



LEGEND

- ▲13GW1 120 MONITORING WELL LOCATION WITH ETHYLBENZENE VALUE
- ND NOT DETECTED
- CONTAMINANT ISOPLETH

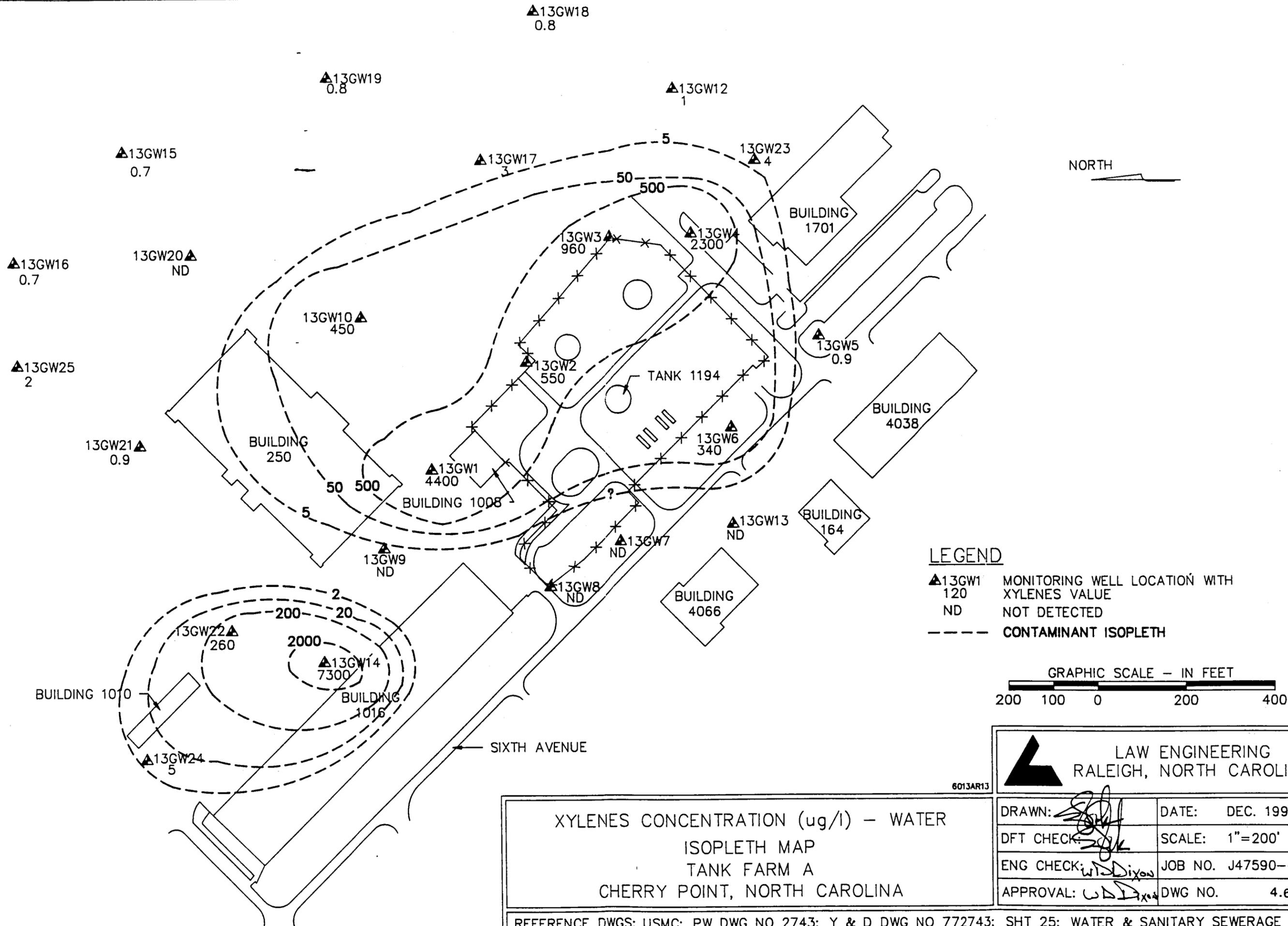


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RALEIGH, NORTH CAROLINA

ETHYLBENZENE CONCENTRATION (ug/l) - WATER
 ISOPLETH MAP
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

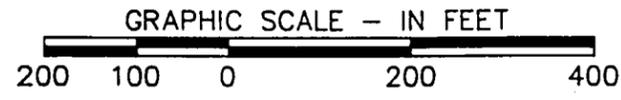
DRAWN: <i>[Signature]</i>	DATE: MAR. 1991
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ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.5

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



LEGEND

- ▲13GW1 120 MONITORING WELL LOCATION WITH XYLENES VALUE
- ND NOT DETECTED
- CONTAMINANT ISOPLETH



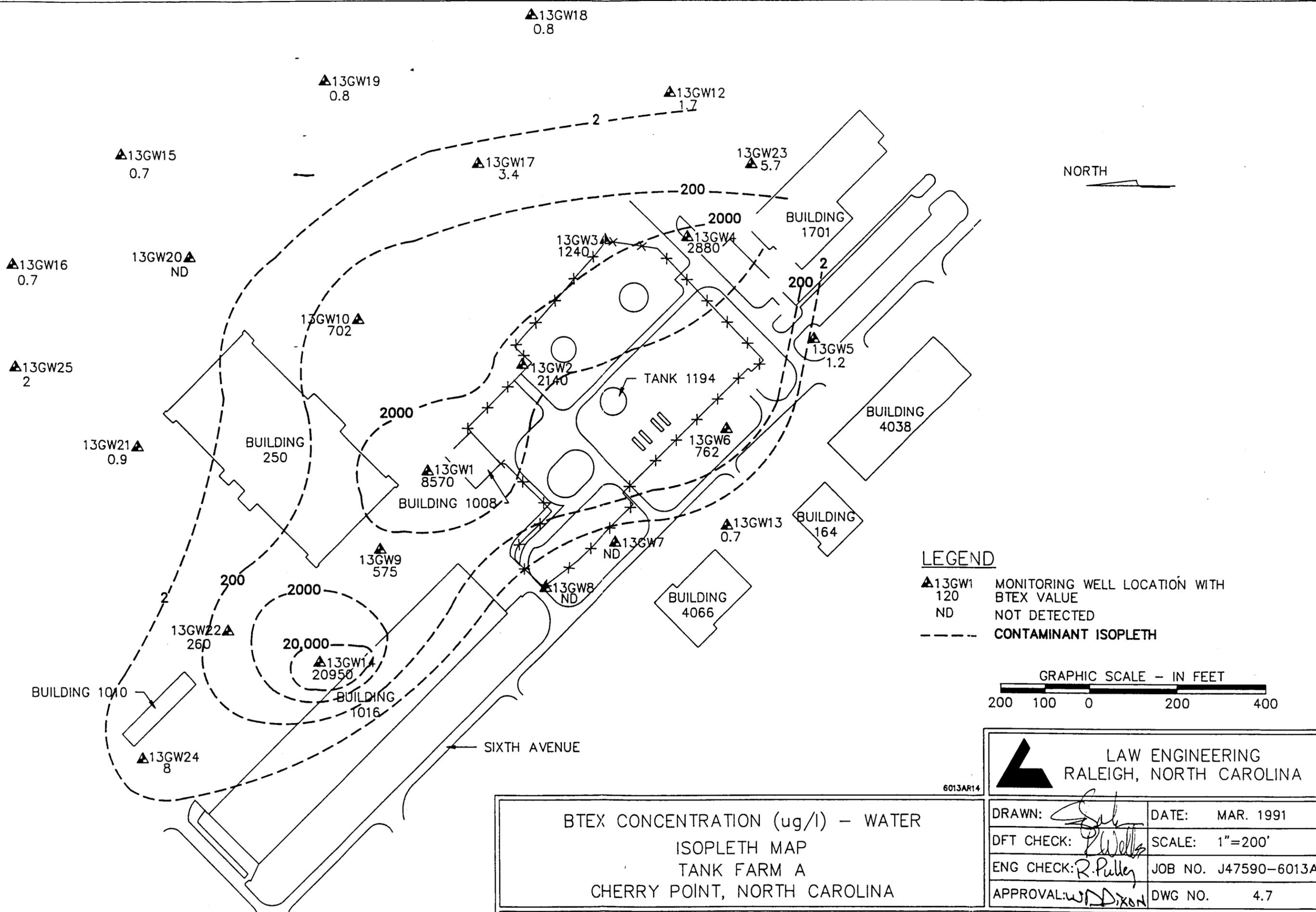
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RALEIGH, NORTH CAROLINA

6013AR13

XYLENES CONCENTRATION (ug/l) - WATER
 ISOPLETH MAP
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>[Signature]</i>	DATE: DEC. 1990
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.6

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.

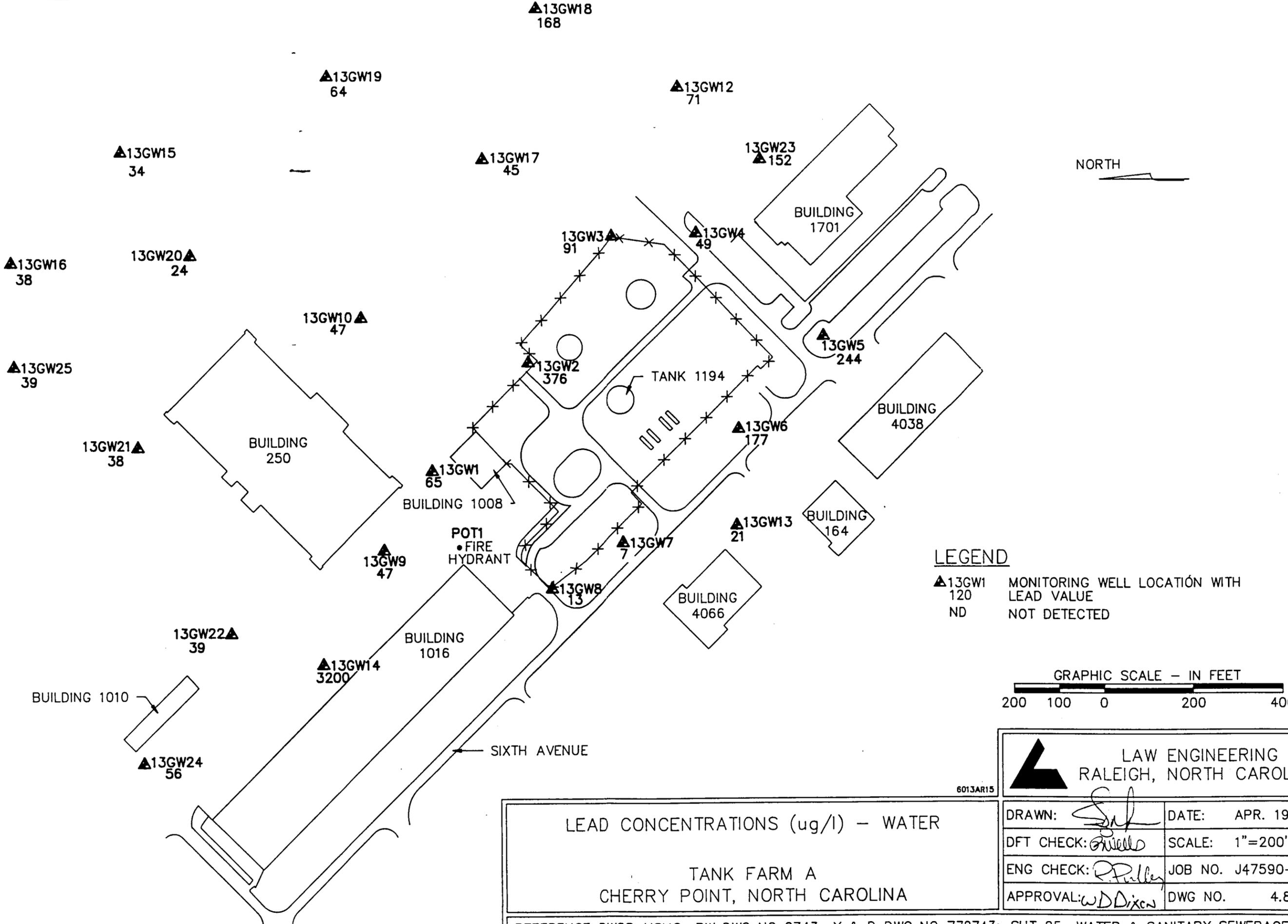


BTEX CONCENTRATION (ug/l) - WATER
 ISOPLETH MAP
 TANK FARM A
 CHERRY POINT, NORTH CAROLINA

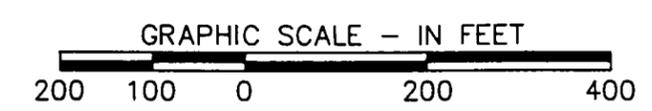
LAW ENGINEERING
 RALEIGH, NORTH CAROLINA

DRAWN: <i>[Signature]</i>	DATE: MAR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.7

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.



LEGEND
 ▲13GW1 120 MONITORING WELL LOCATION WITH LEAD VALUE
 ND NOT DETECTED



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LEAD CONCENTRATIONS (ug/l) - WATER

TANK FARM A
 CHERRY POINT, NORTH CAROLINA

DRAWN: <i>[Signature]</i>	DATE: APR. 1991
DFT CHECK: <i>[Signature]</i>	SCALE: 1"=200'
ENG CHECK: <i>[Signature]</i>	JOB NO. J47590-6013A
APPROVAL: <i>[Signature]</i>	DWG NO. 4.8

REFERENCE DWGS: USMC; PW DWG NO 2743; Y & D DWG NO 772743; SHT 25; WATER & SANITARY SEWERAGE SYS.