FINAL REPORT ON BASELINE HYDROGEOLOGICAL SCREENING SURVEYS STRATEGIC PETROLEUM RESERVE SITES LOUISIANA AND TEXAS

Prepared for

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Section 1.0

ECT
Environmental Consulting & Technology, Inc.

1.0 INTRODUCTION/BACKGROUND

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC. (Louisiana) (ECT) was contracted by Boeing Petroleum Services, Inc. (BPS) to perform Baseline Hydrogeological Screening Surveys (Surveys) for all Strategic Petroleum Reserve (SPR) sites (Figure 1.1-1). The sites surveyed included: Bayou Choctaw, Louisiana; St. James, Louisiana; Weeks Island, Louisiana; West Hackberry, Louisiana; Big Hill, Texas; and Bryan Mound, Texas (Figures 1.1-2 through 1.1-7). These sites are suspected of having been impacted by brine (from salt dome caverns or mines thence to impoundments, disposal wells, and/or disposal outfalls) and hydrocarbons (from crude oil transfer, handling, and storage).

BPS, under U.S. Department of Energy (DOE) prime contract (DE-AC96-85P021431), issued purchase contract SO1M-01541 to **ECT** on September 17, 1992. BPS established a Technical Representative (BTR) at each SPR site through whom scheduled surveys were coordinated. **ECT's** approach to conducting surveys was refined to meet BPS scope-of-work criteria.

The Surveys were designed to employ methods capable of identifying subsurface contamination by 1) brine--through the electromagnetic terrains conductivity method and 2) crude oil (hydrocarbon)--through soil gas analysis. The survey results form the basis for further investigation should verification studies be warranted.

SPR sites for which specific surveys were conducted are as follows:

Brine	Hydrocarbon
Bayou Choctaw	Bayou Choctaw
St. James	St. James
Weeks Island	Weeks Island
West Hackberry (Disposal Wells)	West Hackberry
Big Hill	Big Hill
	Bryan Mound

As well, previously conducted electromagnetic surveys at Bryan Mound and West Hackberry were evaluated and reported.

ECT's project team included subcontracted Soil Testing Engineers, Inc. (STEI) to assist in brine and hydrocarbon survey data analyses, Southern Petroleum Laboratories, Inc. (SPL) for water analyses, and Mr. Joey D. Williams for drafting and related graphics support.

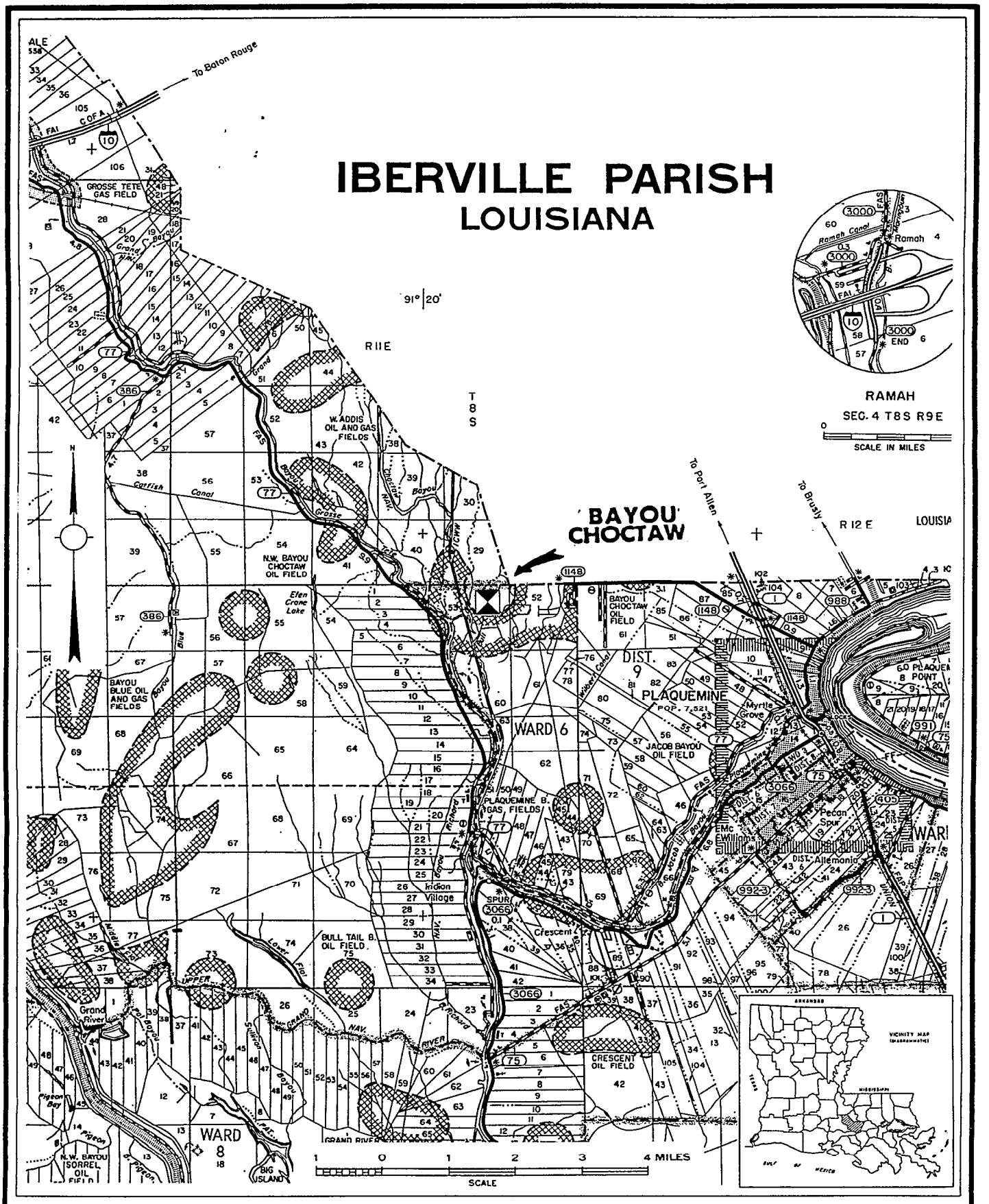

FIGURE 1.1-2.
SITE LOCATION MAP
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: LDOTD, 1989; ECT, 1993.

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Section 2.0

2.0 FIELD INVESTIGATIVE TECHNIQUES & METHODOLOGY

In order to efficiently complete Survey study objectives, **ECT** conducted:

- A limited file review to identify the subsurface geology, occurrence of groundwater, and documentation of spills or environmental impact at each site. Additional Survey screening locations were added in some cases near areas of previously documented releases to better identify the horizontal extent of impact in those areas, if any.

- Site personnel interviews to identify areas of known brine or oil releases to the environment, prior to conducting any field activities.

- Electromagnetic terrain conductivity (EM) surveys with an average measurement interval of 100-feet along proposed transects. The transects were indicated on the base maps of SPR sites as presented in the Solicitation Amendment A-002.

- Soil gas surveys using an average interval of 400-feet along the transects, to depths just above the first water-bearing zone, as identified where possible.

- Hand-augered borings to identify shallow lithology and the first water-bearing zone.

ECT utilized two concurrently operating field crews to conduct the field work. Both crews acquired data simultaneously at the Bayou Choctaw SPR site to establish consistency in data collection techniques and documentation. Upon completion of data acquisition at the Bayou Choctaw SPR site, the crews worked separately at the remaining SPR sites. STEI provided technical assistance, data evaluation, and interpretation of the EM survey data.

Station labels indicated on the tables and figures in this report are indicative of the type of survey performed, as follows:

Station prefix - Surveys performed at station

BO - Both brine (EM) and oil (soil gas) measurements were performed

B - Only brine (EM) measurements were performed

O - Only oil (soil gas) measurements were performed

TW - Sampling and measurement associated with a hand-augered temporary boring; EM measurements were conducted at these stations

MW - Sampling and measurement associated with a pre-existing monitoring well; EM measurements were conducted at some of these stations

OW - Sampling and measurement associated with pre-existing observation wells; EM measurements were conducted at some of these stations

Methodology for conducting limited file reviews is presented in Section 2.1. Section 2.2 presents the methodology for conducting petroleum hydrocarbon impact surveys. The methodology for conducting brine impact surveys is discussed in Section 2.3

2.1 SITE HISTORY, GEOLOGY, AND HYDROGEOLOGY

Literature reviews were conducted to identify the geology, hydrogeology and general history of the various sites. Sources included publications of regional geology and groundwater resources, site-specific reports of previous studies conducted at each site (provided by BPS), and analytical results and monitor well data that had been compiled by BPS personnel but had not yet been evaluated. These reviews were not intended to be comprehensive in nature; their purpose was fulfilled when sufficient information was obtained for this survey concerning overall site geology, zones of groundwater occurrence, groundwater flow direction, areas of known impact to groundwater, and documented brine and/or crude oil releases. Brief interviews were conducted with site personnel knowledgeable of historic brine and/or crude oil

releases to identify areas that may have been significantly impacted. Additional survey stations were added at some of these reported areas to better delineate the lateral extent of potential environmental impact. The investigation of previous releases to the environment was not intended to be comprehensive in nature, and some areas with documented impact may not have been included.

2.2 CRUDE OIL SURVEY

ECT conducted a soil gas survey sampling study using driven probes at all SPR sites. Survey stations were located at approximate intervals of 400 feet along the originally proposed transects. Each station was located by field measurement referenced from surface structures included on the basemaps, and were field identified using color-coded flagging. Some stations were relocated away from the proposed transects to avoid surface or subsurface obstructions at soil gas locations.

Exploratory hand-augered borings were conducted at each site prior to soil gas probing. These borings allowed identification of the near-surface site geology and depth to groundwater. A portion of the hand auger cuttings from each one-foot discrete interval was placed in plastic bags, allowed to stand a minimum of 15 minutes, and the bag headspace was measured for total volatile hydrocarbons using a Foxboro Model 108 organic vapor analyzer (OVA) flame ionization detector (FID).

A sample of groundwater, if encountered, was extracted with a bailer for field measurement of pH, specific conductivity, and temperature. Groundwater samples were prepared for laboratory analyses of Total Petroleum Hydrocarbons (TPH; Modified Method 418.1), Total Dissolved Solids (TDS; EPA Method 160.1) and Salinity (EPA Method 2520 C). Sample preparation and preservations followed the appropriate EPA guidelines. All samples were handled under chain-of-custody control. The TPH method involves extracting the sample with freon, treating with silica gel to remove the polar fatty materials leaving the non-polar hydrocarbon residues, and analyzing the extract using infrared spectroscopy. The TDS method

involves filtration of the sample, drying, and determination of TDS by tare weight. The Salinity method is accomplished by measuring the density of the sample at a controlled temperature.

Upon completion of all sampling activities, each boring was grouted with a portland cement/bentonite mixture meeting LDOTD/LDEQ guidelines in order to eliminate the potential for downward channeling of surface fluids.

A minimum of one soil gas sample per station was extracted and measured on the field OVA FID for total volatile hydrocarbons. The soil gas sampling apparatus consisted of a 7/8-inch diameter steel probe assembly, onto which PTFE tubing was coupled. Soil gas probes consisted of hollow steel tubes, connected internally with threaded tubes, and a carbon steel machined slotted tip. The internal portion of the tubes provided the conduit for sampling of soil gas vapors entering the slotted tip. Gas from the soil flowed through the tubing into a one-liter nalgene flask to capture any fluids pumped during purging prior to passing on to the OVA FID. Figure 2.2-1 is a schematic of the soil gas sampling assembly.

The soil gas probe was driven to within 1-foot of the water-bearing zone (as indicated in the soil borings) using an electric-pneumatic rotary hammer powered by a gasoline-powered portable generator. Advancement of the probe was facilitated by successively adding three-foot long tubing sections, until the desired depth was attained. Removal of the entire probe assembly was facilitated by use of a portable mechanical jack apparatus. Due to the great depth to groundwater at the Weeks Island SPR site, the soil gas surveys there were completed to an average depth of 12 feet.

Upon driving the probe to the desired sampling depth, the probe was briefly pressurized to 30 to 60 pounds per square inch with nitrogen to clear the screen of any smeared soil. The probe assembly was then purged at a vacuum of 9 to 13 inches of mercury for approximately 45 seconds using an electric vacuum pump with

vacuum gauge to remove nitrogen and to ensure proper flow of soil gas into the sampling apparatus (manufacturer's recommendations, KVA Analytical Systems, 1990). The maximum sustained vacuum during purging was recorded and compared to the maximum vacuum attainable by the pump (13 inches) to yield a relative value of gas diffusion potential (a function of soil permeability). This data was later used to qualify non-detected concentrations as attributed to either low permeability strata or soil gas containing no volatile hydrocarbons. Because of the length of the probe screen, a discreet soil interval of approximately four vertical inches was evaluated using this technique.

Once sufficiently purged, the tubing was connected to the OVA FID, the system was purged for approximately 30 seconds, and a reading in parts per million (ppm) of total volatile hydrocarbons was recorded. However, natural soils (especially organic-bearing materials) frequently have a background of naturally-occurring light hydrocarbons. This background was evaluated by the following procedure. An activated charcoal filter apparatus was then connected to the OVA FID to determine the concentration of volatile hydrocarbons attributable to methane and ethane (C^1-C^2) only (hydrocarbons heavier than C^1-C^2 are sorbed onto the activated charcoal, allowing only C^1-C^2 length hydrocarbon compounds to be detected by the instrument). The filtered and non-filtered readings were then compared to yield a reading in ppm as non-C^1-C^2 hydrocarbons, the detection of which would be indicative of crude oil impact.

During the course of the base survey, numerous areas of soil composed of high-plasticity clay were encountered. This clay which would flow into and plug the screen of the probes, resulting in a non-detected concentration of volatile hydrocarbons. The standard procedure for probe advancement and sampling was modified at some locations to include an expendable tip consisting of a wide-head plug (nail) in place of the probe screen. The probe with the expendable tip was driven to the desired depth, the entire probe was retrieved approximately six inches, and the tip was disengaged by pressurizing the probe rods using nitrogen, thereby exposing

approximately six inches of the hole for soil gas extraction. Soil gas purging and measurement was followed from that point. This procedure is referred to in this report as the open-ended probe technique. Intervals of vertical soil profile sampled ranged from a few inches to six feet, determined by the distance the probe rods were retrieved before obtaining a reading.

The level of volatile hydrocarbons detected was verified at some soil gas stations after retrieval of the entire probe rod assembly. A perforated copper rod two feet in length with thick-walled Tygon® tubing attached at the top was lowered into the open hole, the OVA FID was connected to the tubing, the top annulus of the hole was sealed to prevent dilution of the reading by entry of air from above ground surface, and a stabilized reading was recorded. The entire vertical soil profile through the total depth of the hole was sampled using this technique. In this report, this procedure is termed the drop tube verification technique.

Upon initiation of the project, all OVA FID instruments underwent a certified calibration. Calibration was checked/adjusted daily and the instrument was checked against a reference standard a minimum of three times daily for quality control. Upon completion of a site survey, all probe holes were grouted with an aqueous slurried portland cement/bentonite mixture meeting appropriate regulatory guidelines.

2.3 BRINE SURVEY

ECT crews used a Geonics EM-34 variable spacing electromagnetic inductive terrain conductivity meter to conduct the EM brine survey. The EM-34 is a two-man inductive conductivity meter capable of delineating changes in sub-surface conductivities at depths varying from 7.5 to 60 meters (24 to 197 feet). The depth of penetration and resolution are directly related to coil spacing and coil orientation, respectively. To insure the greatest resolution and penetration, **ECT** used two coil spacings (10 and 20 meters) and two coil orientations (horizontal and vertical) at each of the previously marked points on 100-foot intervals. Readings at 40-meter

spacing were conducted at some stations; because interference from structures, powerlines, etc. could be significant at that spacing, readings at 40-meter spacing were not acquired at most stations throughout the base survey. The combination of coil spacings and coil orientations ensured comprehensive conductivity data acquisition to a depth of 30 meters. In general, for the horizontal dipole coil orientation, the relative signal contribution from material near the ground surface is large, and the contribution to response falls with depth. For vertical dipole coil orientation, near surface materials make a very small contribution to the magnetic field.

Two operators, one at the transmitter coil and one at the receiver coil, were used to acquire data. The transmitter coil was placed at the flagged station location. Variations in coil spacing were achieved first, at a 10-meter spacing by, placing coils in the horizontal orientation (vertical dipole mode), and upon recording that reading, placing the coils in a vertical orientation (horizontal dipole mode) and recording that reading. The receiver operator then moved to the 20-meter spacing in the same direction (proper spacing was indicated on the meter). The reading procedure was repeated in the horizontal and vertical dipole modes. Conductivity data from each station was recorded manually in a field logbook by the receiver coil operator. Observations of site attributes, features, and equipment that could have an impact on inductive conductivity readings were noted in the logbook to aid in data interpretation. Relative elevations at each station were visually approximated at the Bayou Choctaw, West Hackberry, St. James Terminal, Weeks Island, and Bryan Mound sites. A site-specific topographic contour map was referred to for station elevation data at the Big Hill site. A schematic of the EM procedure is given on Figure 2.3-1.

STEI reduced the field EM data (where possible) using the Multivariate Least-Squares Regression-Prediction (MVRP) statistical method (Boutwell and Lawrence, 1988, and Lawrence and Boutwell, 1990). This procedure assumes that some relationship exists between the groundwater chemistry (specific conductance or

dissolved solids, primarily) and the EM readings. This procedure requires a knowledge of the lithology plus measurements of the groundwater ionic characteristics within the aquifers. MVRP is used to establish a mathematical relationship between the measured groundwater chemistry (in this case, specific conductivity or total dissolved solids) at various points ("hard data") and the EM readings at those points. The relationship is then used to predict the groundwater chemistry at locations where only EM data was measured with no direct measurement of the groundwater chemistry ("soft data"). The MVRP method requires a sufficient number of stations with measured values of groundwater chemistry (specific conductivity or total dissolved solids) in order to predict with an acceptable degree of confidence the groundwater chemistry.

The mathematical formula which was used to model the groundwater chemistry - EM readings relationship has the general linear form:

$$F(y) = a + bG(x_1) + cH(x_2) + dI(x_3) + \ldots \qquad \text{(Eq. 1)}$$

where: y = Dependent Variable (such as TDS, Specific Conductivity)

x_n = Independent Variables (such as EM readings) n = 1,2,3...

a,b,c,d = Regression Constants

F,G,H,I = Functions of Variables

The reliability or confidence level of the regression can be evaluated through the regression parameters: Coefficient of Correlation (C_c) and Standard Estimate of Error (SEE). The former indicates the reliability of the prediction, the latter its precision. A qualitative guide to reliability (C_c) is (Guilford, 1950):

C_c (Abs. Value)	Strength of Relationship
Less than .20	Slight; almost negligible relationship
.20 - .40	Low correlation; definite but small relationship
.40 - .70	Moderate correlation; substantial relationship
.70 - .90	High correlation; marked relationship
.90 - 1.00	Very high correlation; very dependable relationship

SEE is the standard deviation of the differences between predicted and observed values. It can be used to evaluate the precision of the predicted values. In ordinary statistics, the precision can be expressed by:

$$Q = P(Zp - FxSEE \leq Z \leq Zp + FxSEE) \qquad \text{(Eq. 2)}$$

where: P = Probability
Z = Actual Value of Z
Zp = Predicted Value of Z, from Eq. 1)
F = Standardized Normal Function of Level Q

Factor F is tabulated in most texts on statistics. This factor depends on the number of hard data points and the probability (level of confidence) that a certain proportion of the actual values will fall within the range defined by Equation 2.

The advantages of MVRP are:

1. The EM survey serves as an extension of hard data, rather than a method which has to be correlated with additional hard data or another geophysical method.

2. The results from MVRP are in terms of concentration with no further data reduction necessary.

Sufficient measurements of groundwater chemistry were available at the Bayou Choctaw and Big Hill sites to obtain acceptable correlations; therefore, MVRP analysis was used for these sites. Direct contouring of the EM readings was used for all sites to evaluate any possible anomalies.

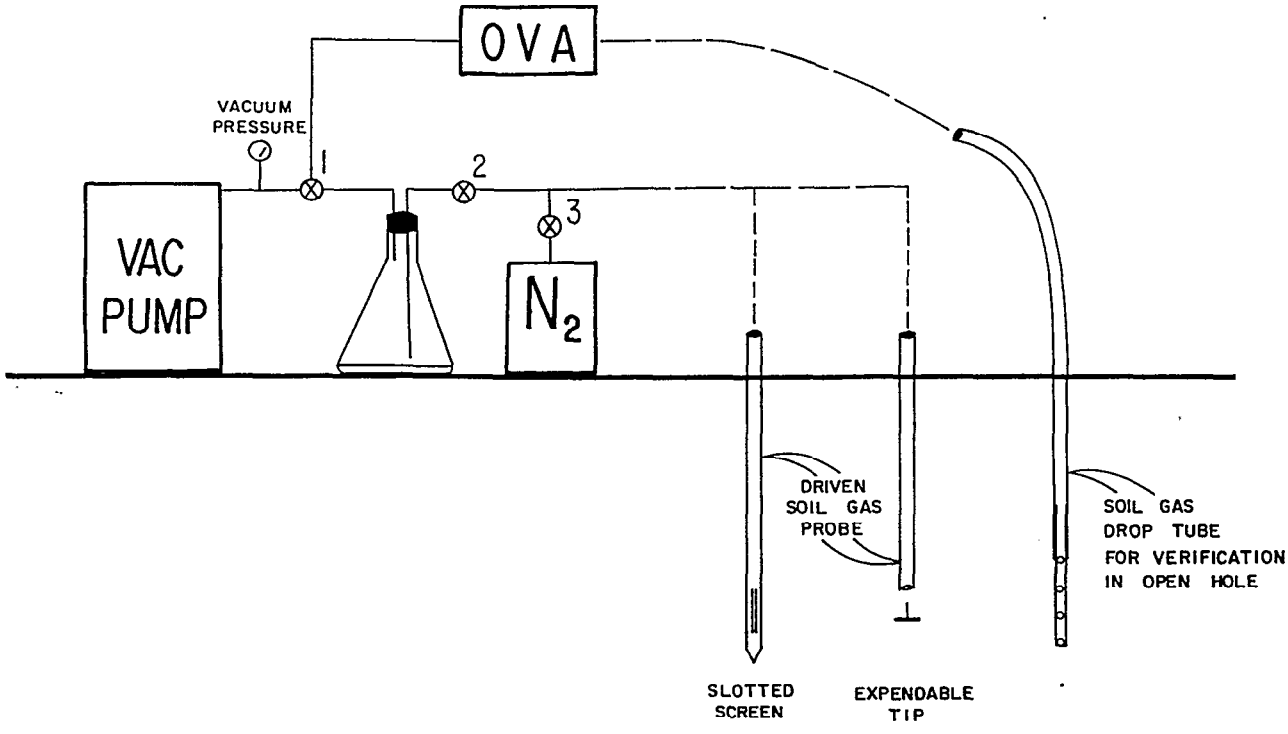

FIGURE 2.2-1.

SOIL GAS SAMPLING APPARATUS SCHEMATIC
BASE SURVEY, BOEING PETROLEUM SERVICES, INC.

Source: ECT, 1993.

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Section 3.0

3.0 RESULTS AND INTERPRETATION

3.1 BAYOU CHOCTAW SPR SITE

3.0 RESULTS AND INTERPRETATION

3.1 BAYOU CHOCTAW SPR SITE

3.1.1 SITE HISTORY

The Bayou Choctaw Salt Dome was discovered in 1926 by the Texas Gulf Sulfur Wilberts No. 3 well, and oil was first discovered in 1931 by Standard Oil of Louisiana; the salt dome has been the site of extensive oil and gas development since. Allied Chemical Corporation (Allied) has drilled over 20 brine wells on the dome since 1937. The DOE purchased 11 leached caverns from Allied in 1976 as part of the DOE SPR crude oil storage facilities.

The Tobin map of the Bayou Choctaw Field indicates that over 50 producing wells have been located within the bounds of the current DOE property. A concentration of wells was located along the southern edge of the current brine pond, and just west of Cavern 20. The majority of these wells have since been plugged and abandoned (P&A'd); impact to subsurface soils and groundwater from former drilling production activities at these wells is possible.

Personal communication with site personnel indicated that crude oil and/or heavy gravity hydrocarbons were encountered in shallow soils near the high-pressure pump pad near Cavern 15, and east of the oil-brine separator located east of the brine pond. No documented records of releases at this site were reviewed by ECT.

3.1.2 GEOLOGY/HYDROGEOLOGY

The Bayou Choctaw site topography is characterized as flat to very gently sloping; topographic variation is the result of grading and filling associated with the construction of site facilities. The U.S. Department of Agriculture (USDA) Soil Survey classifies the surficial soils as Sharkey clays, with a horizontal permeability with respect to water of less than 0.06 inches per hour. Water infiltration capacity is poor, and the soil classification is considered to pose a high corrosion risk.

A "Geological Site Characterization, Bayou Choctaw Salt Dome" report dated September 1980 by Acres American, Inc., was referenced for identification of subsurface geology. Figure 3.1-1 is a geologic cross section across the site; the cross section was compiled by Sandia National Laboratories from data logs of area oil and gas wells. The top of the salt dome is between 600 to 700 feet below land surface (bls). A caprock consisting of a lower gypsum-anhydrite layer of varying thickness (100 to 150 feet) exists directly over the salt, underlying an upper clay and gypsum complex approximately 100 feet in thickness. Caprock structure therefore exists as shallow as 380 feet bls.

The principal aquifer at this site is the Plaquemine Aquifer which occurs at a depth of 60 to 500 feet bls. The aquifer is comprised of the Shallow Plaquemine Sand (60 to 170 feet bls), the Prairie Clay aquitard (170 to 230 feet bls), and the Gonzales Sand (230 to 600 feet bls). The fresh/brackish water interface occurs approximately 400 to 500 feet bls.

The Atchafalaya Clay occurs at land surface and extends to a depth of 60 feet. Boring logs describe this stratum as a soft gray clay with silt layers and organic matter. The Mississippi River channel cuts through the Atchafalaya Clay, thus allowing direct hydraulic connection with the Plaquemine Aquifer. The Atchafalaya Clay functions as a confining layer to the aquifer. Groundwater flow in this aquifer is generally influenced by the stages of the Mississippi River; when the stage is low, flow is generally toward the river, and when river stage is high, the direction reverses.

Three hand-augered soil borings were completed to the first observed groundwater by **ECT**. Logs of the borings can be found in Appendix A. The borings encountered stiff clay to a depth of six feet, with areas of fill consisting of clayey gravel, and anhydrite. Groundwater was encountered at a depth of four feet in soft clay intervals in the two borings located near the brine pond and at the brine disposal well pads, and at two feet deep in the third boring near Cavern 20. This first occurrence of groundwater is believed to exist as a perched "water table" in a zone of low hydraulic

conductivity, because temporary wells placed in the borings could be bailed dry, and a minimum of eight hours was required for wells to recharge to within 80% of pre-bailed levels.

Impact to groundwater by brine in a water-bearing sand encountered at 20 to 28 feet bls (believed to be a localized more-permeable strata within the Atchafalaya Clay) has been documented through sampling four monitor wells (MW-1, MW-2, MW-3, and MW-4) around the brine pond. Groundwater analytical results from monthly sampling events during 1990 through 1992 revealed Salinity concentrations averaging 85 parts per thousand (ppt) at the southeast corner of the brine pond, with average concentrations of 40 ppt extending approximately 250 feet southeast of the brine pond. Salinity concentrations averaged 20 ppt at the southwest corner, and 13 ppt at the northern edge of the brine pond. These average concentrations have not increased or decreased significantly in the previous two years of monitoring. Top of casing elevations were not available for these wells, so direction of groundwater flow could not be determined; however, depths to groundwater measurements indicated that groundwater fluctuated seasonally, approximately three feet during the two years of monthly measuring.

A water supply well, located approximately 150 feet northeast of the brine ponds is completed at a depth of 100 to 120 ft bls in the Shallow Plaquemine Sand. The well produces potable water for industrial use (washwater, etc.). No incidence of brine impact associated with this well has been documented (the drinking water standard for sodium chloride is 25 ppm).

Samples of groundwater were extracted from each temporary well (TW-1, TW-2, and TW-3) installed during base survey activities for analysis of TDS, Salinity, and TPH; additionally, BPS site personnel acquired duplicate samples during monthly sampling of the brine pond wells for analysis of TDS. Groundwater inadvertently pumped during soil gas sampling at BO-85 and 0-103 was analyzed for TPH, yielding 9.0 micrograms per liter (mg/L) and 12 mg/L, respectively. Results of these analyses

are summarized in Table 3.1-1. Laboratory analytical results can be found in Appendix B.

TDS results from brine pond monitor wells ranged from 16,100 mg/L to 77,400 mg/L in MW-1 and MW-3, respectively; Salinity results for the same two wells were 14.1 ppt and 69 ppt, respectively. Temporary well TW-1, installed 150 feet east of the brine reservoir, exhibited TDS and Salinity results of 27,300 mg/L and 28.6 ppt, respectively. These results indicate that 1) the dissolved solids are primarily saline, and 2) the plume extends some distance east of the brine pond. Results of TPH in groundwater from TW-1 and from BO-85 (at the location of observed crude oil impact) were 9.8 mg/L and 9.0 mg/L, respectively, suggesting that impact by crude oil as observed near the brine/oil separator extends some distance to the east.

Temporary well TW-2, installed north of Cavern 101, exhibited no appreciably elevated levels of Salinity or TDS. The TPH result from the groundwater sample in that well was 2.5 mg/L. Well TW-3, installed near Brine Disposal Well Pad No. 1 located approximately 3 miles south of the cavern areas, exhibited TDS and Salinity levels of 3,880 mg/L and 2.66 ppt, respectively.

3.1.3 CRUDE OIL SURVEY RESULTS

A total of 32 stations at the Bayou Choctaw site were evaluated for volatile hydrocarbon concentrations in soil gas. The location of survey stations are depicted on Figure 3.1-2 (main site) and Figure 3.1-3 (brine disposal well pad area). Methods used included the standard screened driven probe, the expendable-tip probe, and verification with the drop tubing. Additionally, a soil gas result at TW-3 is reported resulting from headspace analysis of soil cuttings. Results of soil gas analyses are presented in Table 3.1-2 and on the site map in Figure 3.1-4. Groundwater from two temporary wells (TW-1 and TW-2) and from two soil gas stations (O-103 and BO-85) was analyzed for TPH. Crude oil survey evaluations occurred from November 3, 1992 through January 12, 1993. Six stations exhibited non-detected concentrations attributed to low-permeability soils. Qualitative measurements were not obtained at

two stations due to the shallow occurrence of groundwater which was pumped inadvertently during purging. As previously indicated, laboratory analyses were performed on samples from these two stations.

The 400-foot spacing interval specified in the Purchase Contract yields data that more closely approximates a series of discrete point measurements, as apposed to more closely spaced intervals that would better detect lateral variations in soil gas volatile hydrocarbon concentration. The data was therefore contoured to better identify discrete zones exhibiting anomalous soil gas levels. Additionally, the depth of first-encountered groundwater varied considerably at this site, thereby limiting the degree to which soil gas readings could be laterally correlated.

Crude oil was observed by BPS personnel in an excavation adjacent to BO-85, near the oil-brine separator east of the brine reservoir. A soil gas reading of 6.5 ppm was measured at BO-85 at a depth of 2.6 to 2.9 feet bls (water was encountered and sampled) on November 5, 1992. The station was resampled on January 12, 1993 in an adjacent hole at a depth of two feet bls, with a result of 240 ppm as non-C^1-C^2. The considerable variability could be caused by differences in soil temperature, soil moisture, or to random variability in sampling. A detection of 5 ppm or greater is therefore interpreted to be possibly indicative of impact by crude oil. Areas considered as exhibiting anomalies during the crude oil survey are as follows:

- The area near the brine-oil separator east of the brine reservoir is interpreted to extend to the southeast to east of Cavern 18, and possibly northwest near station BO-94. Crude oil was observed by BPS personnel in an excavation adjacent to BO-85 (soil gas of 240 ppm), and groundwater pumped during the original sampling at BO-85 exhibited TPH concentrations of 9.0 mg/L. TW-1, located approximately 80 feet southeast of BO-85 exhibited a TPH concentration of 9.8 mg/L.

- Soil gas readings of 500 ppm and 18 ppm were detected near Cavern 20. The high soil gas flow rates encountered during sampling at these stations increases the level of confidence in the results. The literature review revealed that a density of oil and gas well locations existed just west of Cavern 20, and Figure 3.1-4 indicates concentrations increasing toward the west.

- Station BO-115 on the west side of Cavern 19 exhibited a reading of 20 ppm; volatile hydrocarbons were not detected in the probing on the east side of Cavern 19 suggesting that impact, if present, is localized.

- Three stations were sampled near the spare parts warehouse, near the underground storage tank (UST) system. Although only two low results (1.5 ppm and 2.0 ppm) were obtained, the very low gas flow rate measured while sampling these locations could be indicative of low-permeability soils at the depth of investigation. Groundwater pumped during the sampling of O-103 exhibited a TPH concentration of 12 mg/L, suggesting that groundwater impact could exist in this area.

Volatile hydrocarbons were detected at low concentrations at a few isolated stations distant from the areas previously discussed. The low concentrations suggest that extensive impact by hydrocarbons containing a volatile fraction probably does not exist in those areas.

3.1.4 BRINE SURVEY RESULTS

EM terrain conductivity measurements were obtained at 164 stations throughout the Bayou Choctaw site and brine disposal well area. Variations in readings were observed at a number of stations at which the EM receiver was positioned in differing directions relative to the transmitter. Anomalous readings were discarded where evidence of interference by powerlines, surface structures, or buried structures was suspected; otherwise, the multiple readings were averaged for the station.

Results of EM readings are summarized in Table 3.1-3; maps including contours of equal instrument response (in mmho/m) at 10-meter spacing (shallow depth of investigation) and at 20-meter spacing (deeper depth of investigation) at the storage facility are presented in Figures 3.1-5 and 3.1-6. Maps with contours of equal instrument response at 10-meter and 20-meter coil spacing at the brine disposal well pad area are presented in Figures 3.1-7 and 3.1-8.

The MVRP analysis (see Section 2.3) was conducted by STEI for the data from this site , using Salinity and TDS results from groundwater samples. A very satisfactory correlation was established at the six hard data points between TDS measurements and the EM readings. The "best-fit" regression was:

$$\text{Log(TDS)} = 3.113 - 5.773\ \text{Log(R1)} + 0.370\ \text{log(R2)} + 5.726\ \text{Log (R3)}$$

TDS = Total Dissolved Solids in ppm
R1 = EM reading, 10 meter Horizontal Dipole
R2 = EM reading, 10 meter Vertical Dipole
R3 = EM reading, 20 meter Horizontal Dipole

The resulting contours of predicted TDS concentration are shown on Figure 3.1-9 for the Bayou Choctaw site.

The Coefficient of Correlation (C_c) is 0.95 and the logarithmic Standard Estimate of Error (SEE) is 0.244. The reliability is very high using the Guilford criterion. The accuracy of the correlation is high. There is about 90% probability that 90% of the actual values will fall within the range of 75% to 133% of the predicted values.

In general, contours of raw EM data (instrument reading) and predicted TDS concentrations are in good agreement. The high anomaly east of Cavern 17 is interpreted to be due to buried pipelines in the area. Five areas exhibiting elevated EM values and predicted TDS values are as follows:

- A large area of brine impact in groundwater around the brine reservoir is indicated, extending north to Cavern 15, and south to the east-west canal. This anomaly is believed to be continuous with the anomaly near MW-4; the lowering of contour values as shown of Figure 3.1-9 between MW-4 and the brine reservoir is believed to result from surface interference.

- An anomalous area of elevated EM readings and predicted TDS concentrations is indicated near the spare parts warehouse, extending north to Cavern 101. This area coincides with the former location of a producing well.

- A small area of elevated predicted TDS concentration exists south of the administration building at the road intersection. Although the area of predicted impact is limited in size, it should be noted that no EM control was obtained near Cavern 102, or in the swamp to the east; additional data at these locations could result in a larger predicted area of impact.

- Elevated predicted TDS concentrations and high EM readings were observed at the western edge of Cavern 20. Predicted concentrations appear to increase in the westerly direction. As was previously mentioned, a concentration of oil and gas well locations located just west of Cavern 20 was observed on the oilfield Tobin map.

- A small area of elevated EM readings and predicted TDS concentrations is indicated on the northeast corner of Cavern 19. EM data control was only obtainable along the perimeter of the cavern, and along the access road, since the area was surrounded by water.

The MVRP method was not used to predict contaminant concentration at the brine disposal well pads, since no "hard data" existed from these outlying areas. Rather, EM response at differing coil spacing and orientation was contoured to identify lateral trends; Figure 3.1-7 is contoured EM data at the shallow depth of investigation (10-meter spacing, and horizontal dipole orientation). Figure 3.1-8 represents contoured EM data at the deeper depth of investigation (20-meter spacing, and vertical dipole orientation). Results of the survey are as follows:

- Elevated EM readings were observed around each brine disposal well pad; readings decreased radially with distance from each well pad. An area of high EM readings at the shallow depth of investigation was noted south of Brine Disposal Well Pad No. 1; elevated readings appeared to extend south and further east of this pad at the deeper depth of investigation. EM readings at Brine Disposal Well Pads No. 2 and No. 3 showed no lateral trends other than increasing near each well pad.

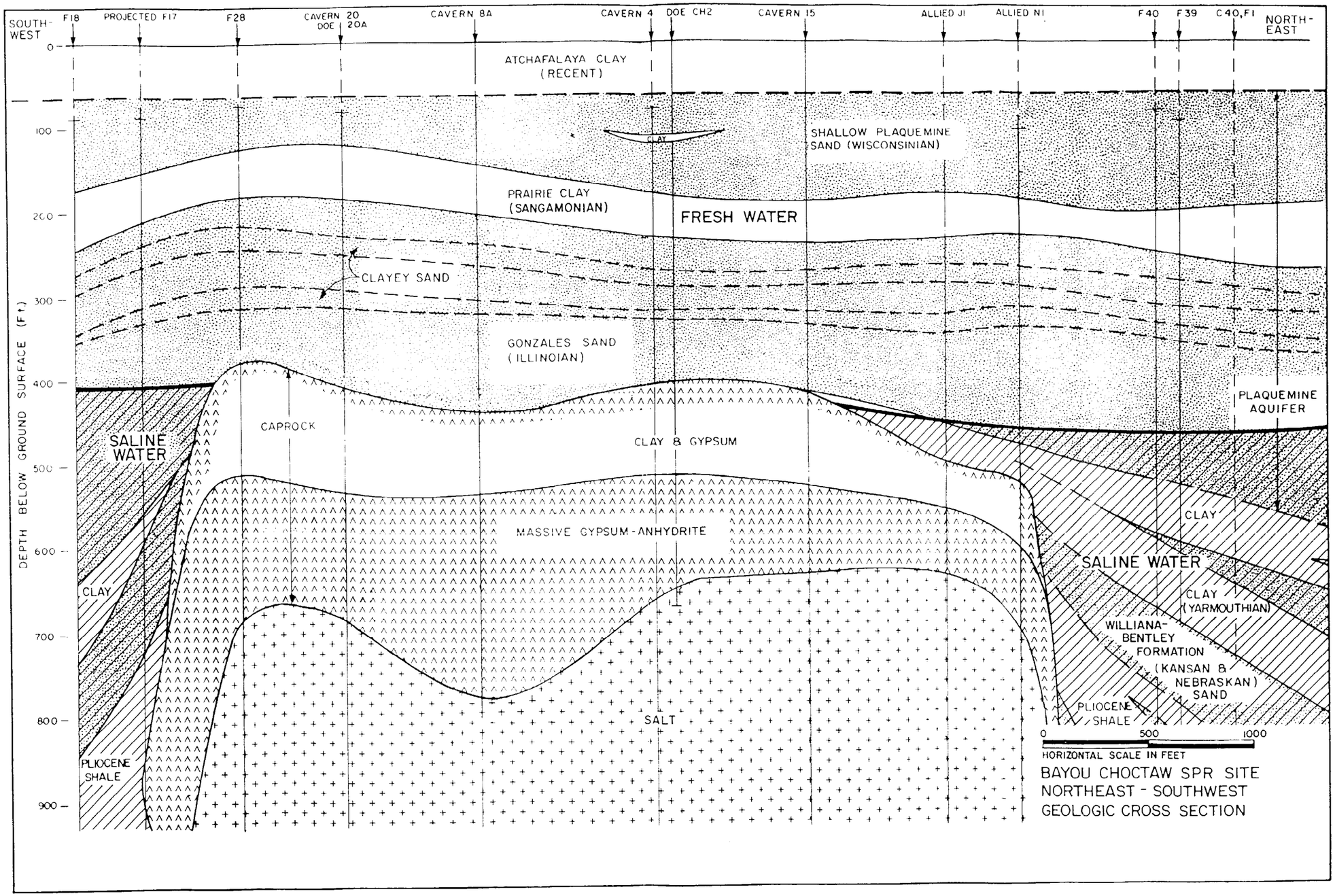


FIGURE 3.1-1
GEOLOGIC CROSS-SECTION
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Sources: Sandia National Laboratories, 1980; ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

NORTH

LEGEND

BO Brine and Oil Survey Station

B Brine Survey Station

MW Monitoring Well

TW Temporary Well

0 500

SCALE (FEET)

FIGURE 3.1-2
SURVEY STATION LOCATIONS
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

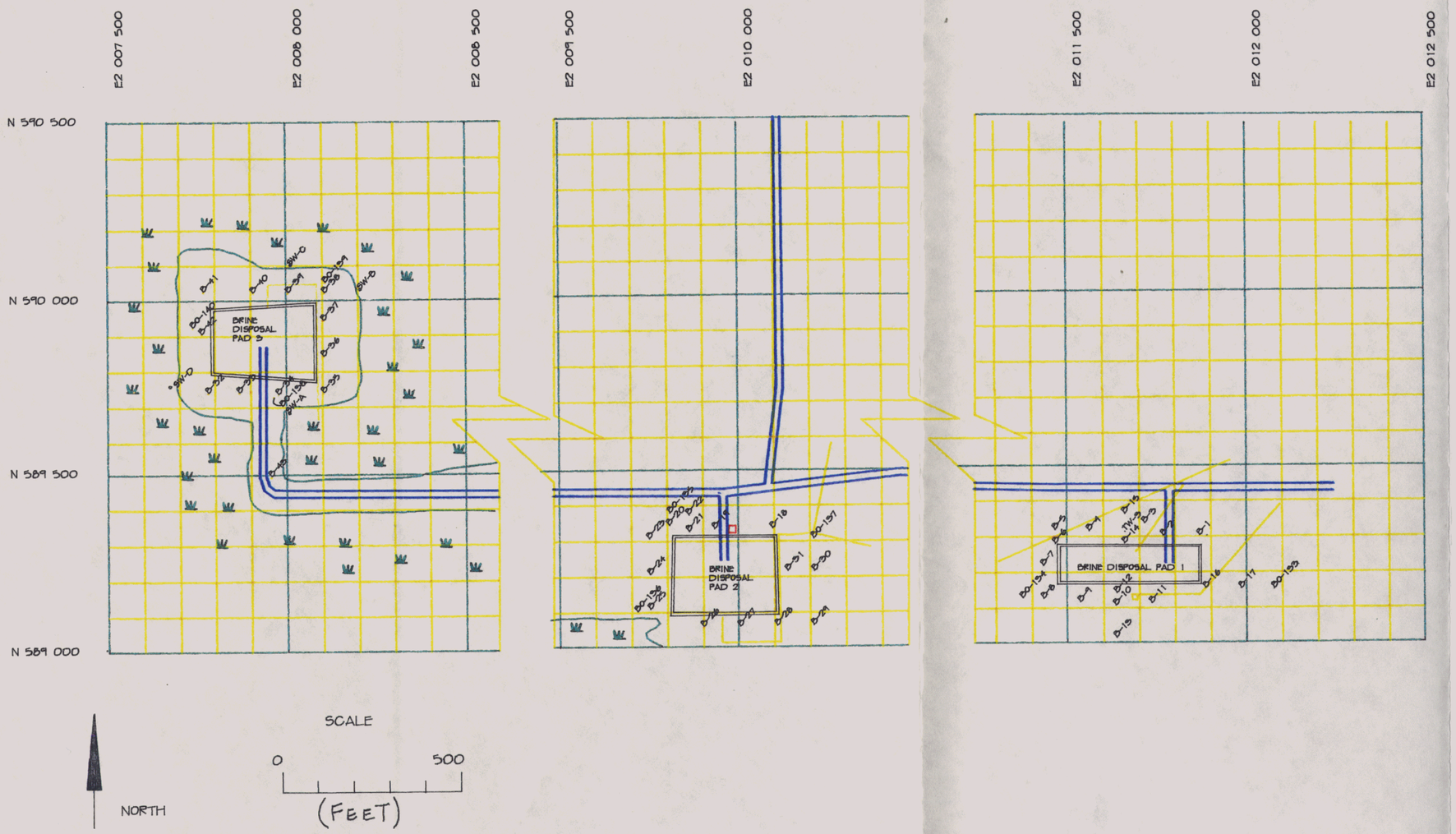
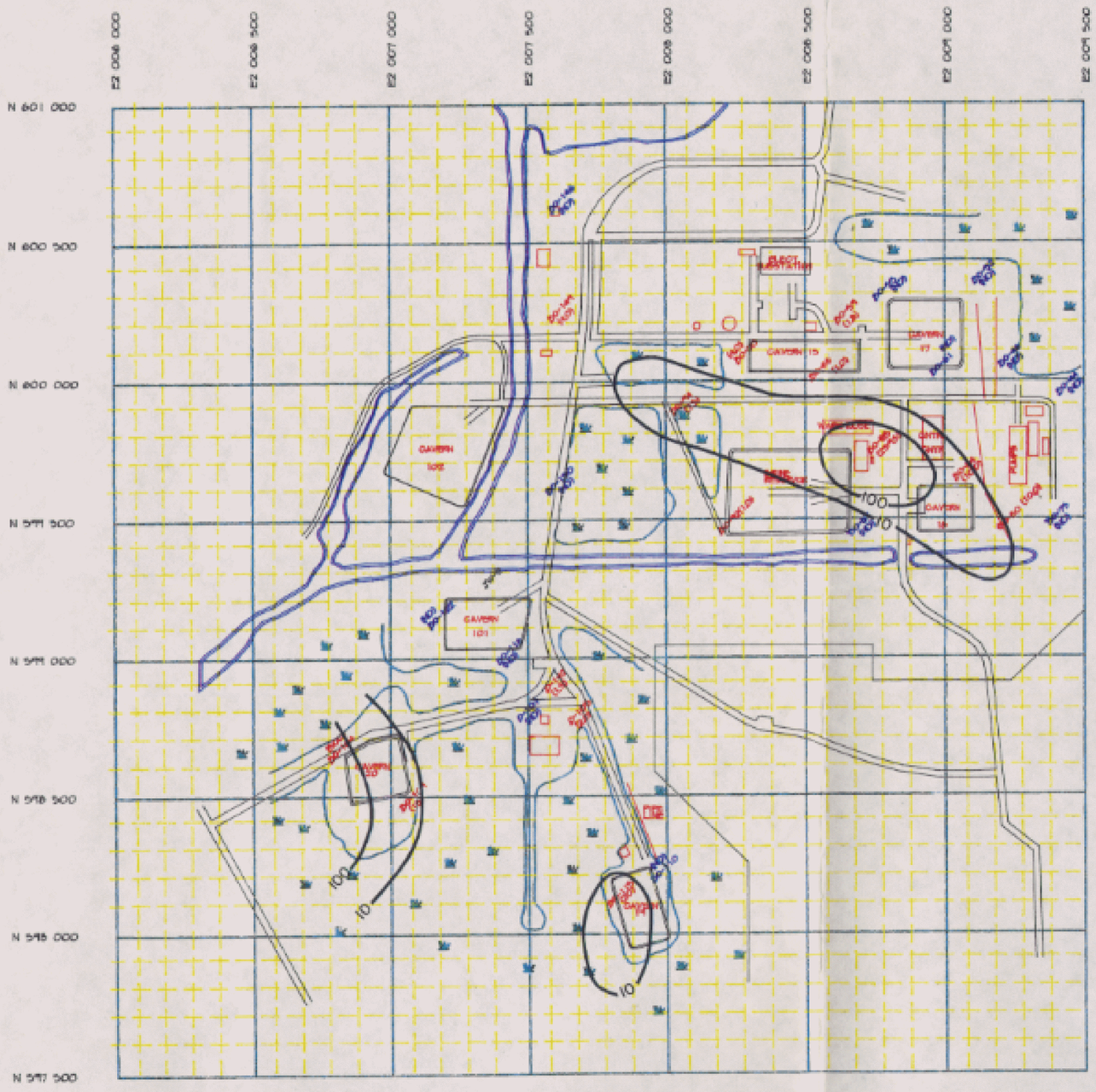


FIGURE 3.1-3
SURVEY STATION LOCATIONS
BAYOU CHOCTAW DISPOSAL WELL PADS
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.



NORTH

LEGEND

044 SOIL GAS MEASUREMENT LOCATION

ND SOIL GAS CONCENTRATION LESS THAN 1.0 PPM NON-METHANE/ETHANE VOLATILE HYDROCARBONS

(5.0) SOIL GAS CONCENTRATION IN PPM AS NON-METHANE/EHTANE VOLATILE HYDROCARBONS

LP NON-DETECTED SOIL GAS CONCENTRATION INTERPRETED DUE TO LOW-PERMEABILITY STRATA

FO READING NOT OBTAINED DUE TO REPEATED FLAME-OUT OF FID, DUE TO LOW SOIL OXYGEN LEVELS

WTR READING NOT OBTAINED DUE TO GROUND-WATER ENTERING SOIL GAS APPARATUS

NOTES:

VALUES INDICATED REPRESENT THE HIGHEST NON-METHANE/ETHANE VOLATILE HYDROCARBONS MEASURED AT THAT LOCATION. IF MORE THAN ONE READING WAS OBTAINED. ALL MEASUREMENTS CONDUCTED WITH A FOXBORO MODEL 108 ORGANIC VAPOR ANALYZER - FID

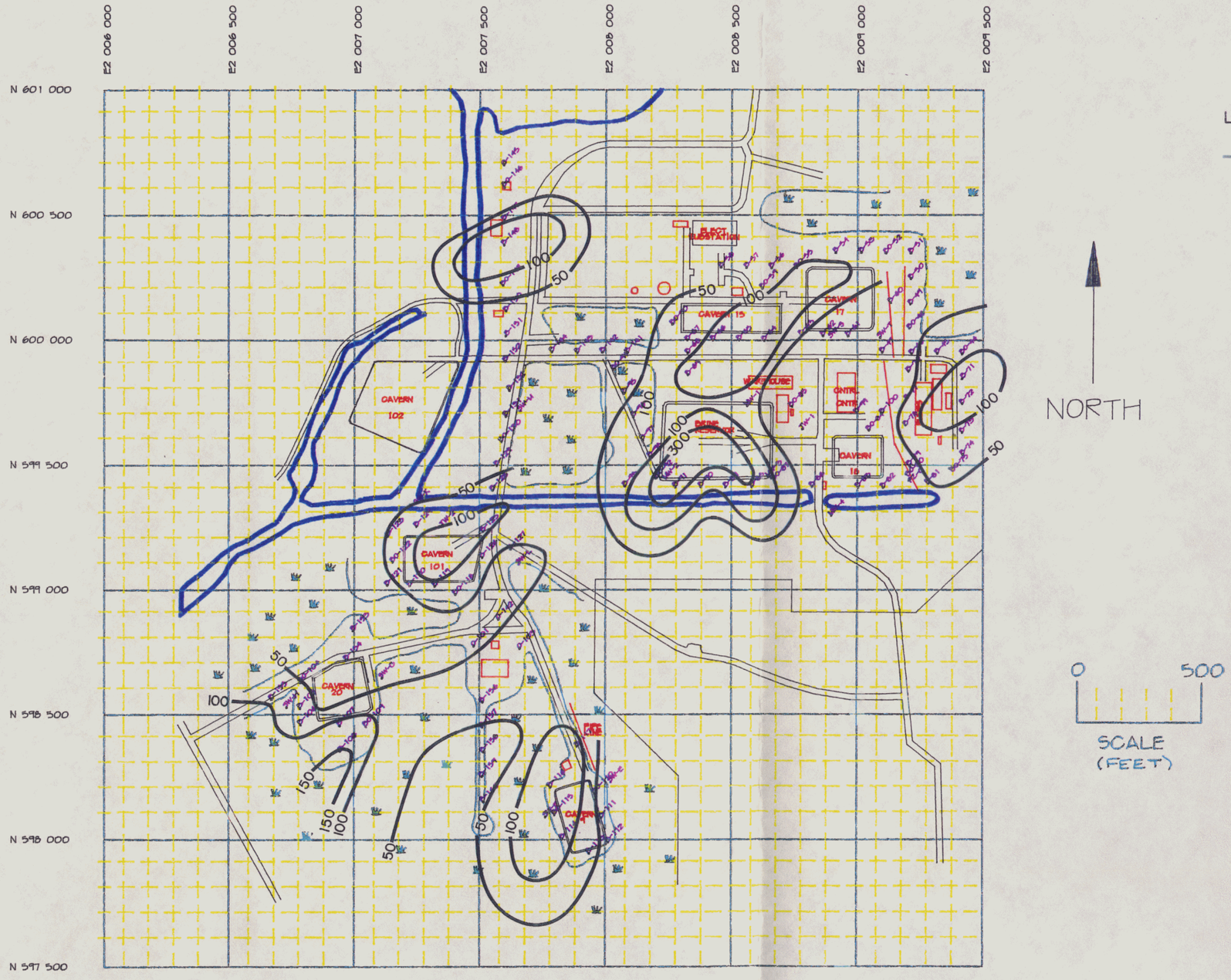
VALUES AT TEMPORY WELL LOCATIONS (TW) CORRESPOND TO OVA HEADSPACE READINGS OF SOIL SAMPLE INTERVAL IMMEDIATELY ABOVE WATER-BEARING ZONE

0 500

SCALE (FEET)

FIGURE 3.1-4
SOIL GAS SURVEY RESULTS
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

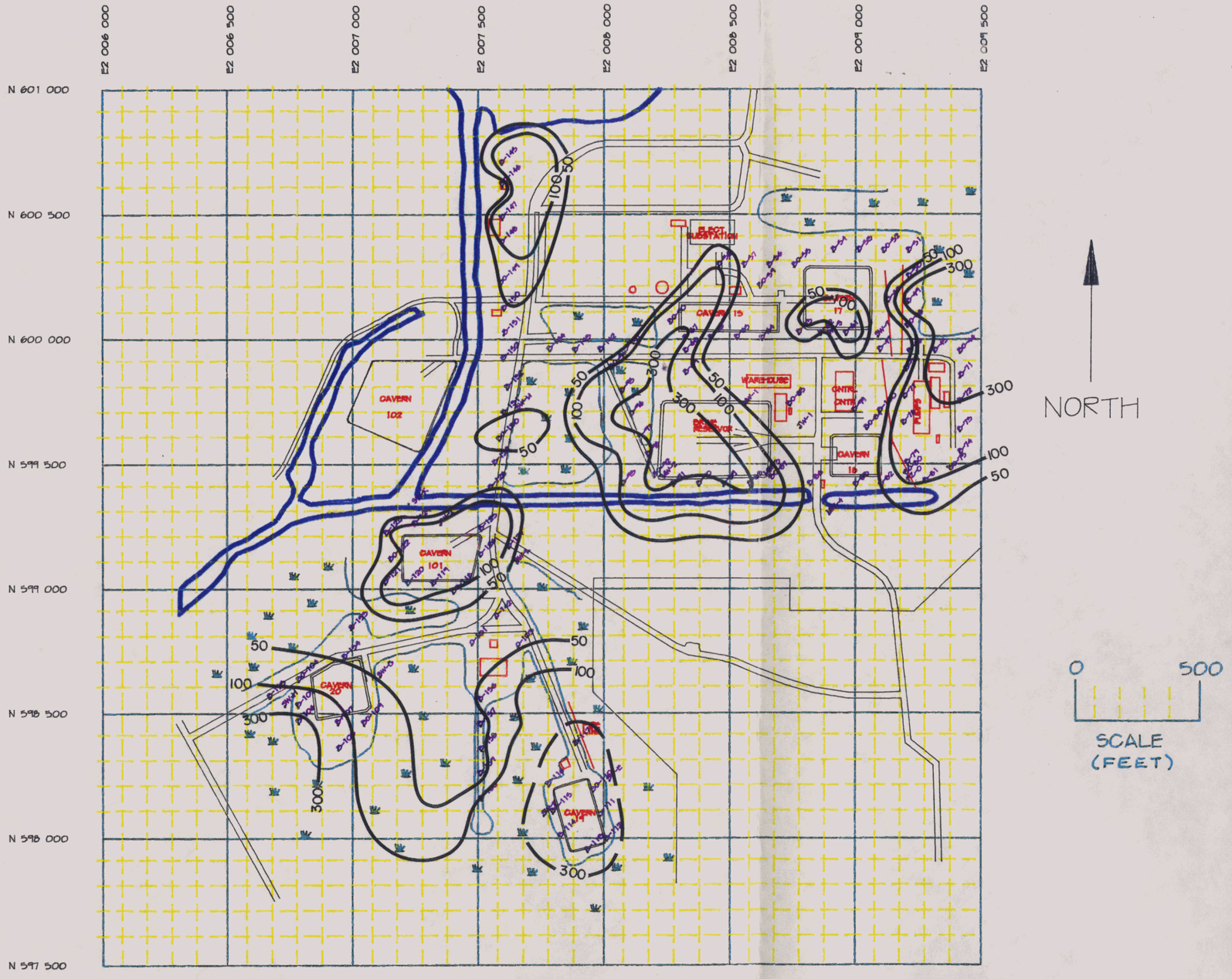


Legend

50 — Contour of equal EM instrument apparent conductivity reading (mmho/m)

FIGURE 3.1-5
ELECTROMAGNETIC TERRAIN CONDUCTIVITY RESULTS - SHALLOW DEPTH OF INVESTIGATION
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.



Legend

50 — Contour of equal EM instrument apparent conductivity reading (mmho/m)

FIGURE 3.1-6
ELECTROMAGNETIC TERRAIN CONDUCTIVITY RESULTS - DEEP DEPTH OF INVESTIGATION
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

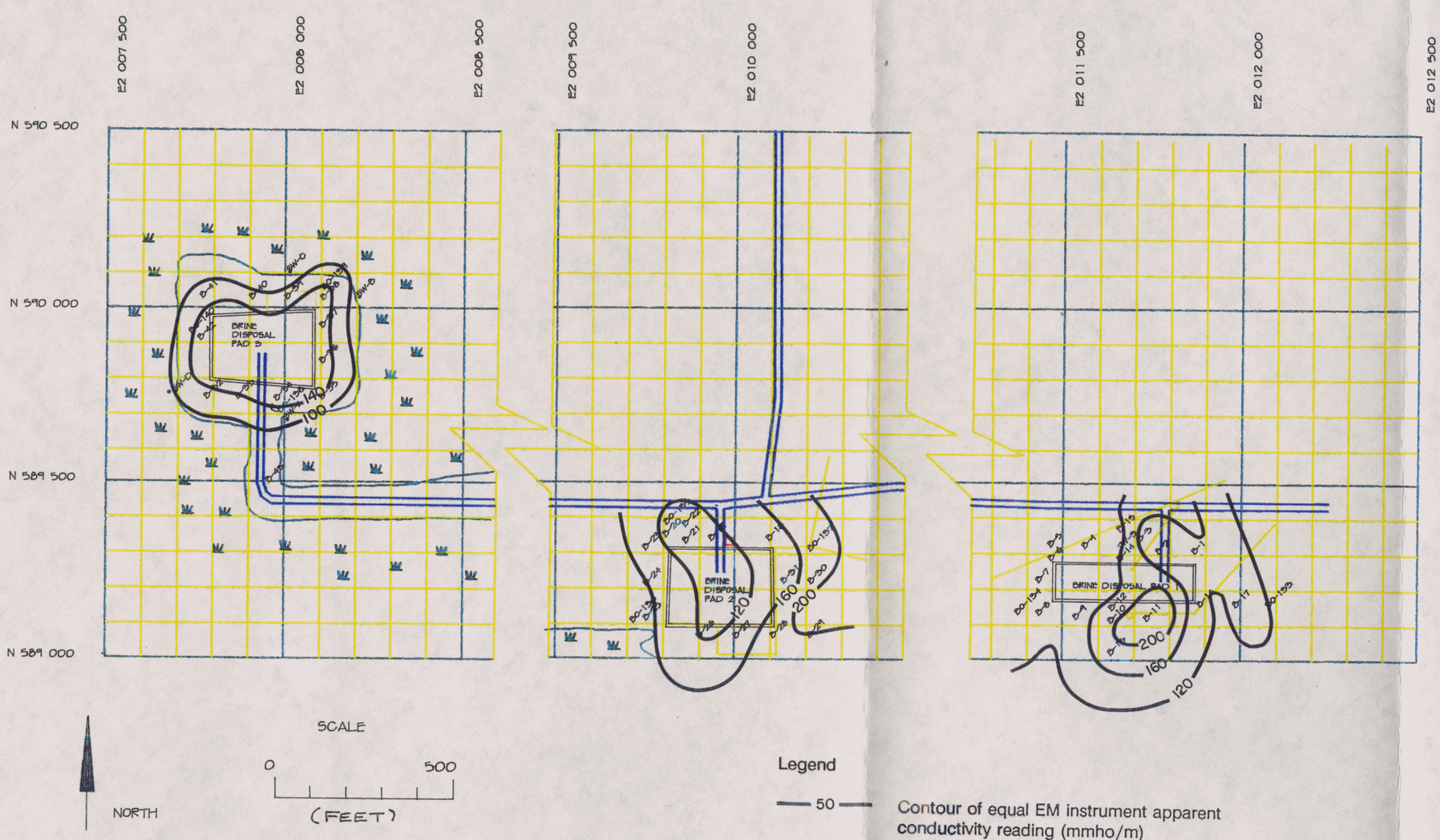


FIGURE 3.1-7
ELECTROMAGNETIC TERRAIN CONDUCTIVITY RESULTS - SHALLOW DEPTH OF INVESTIGATION
BAYOU CHOCTAW DISPOSAL WELL PADS
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

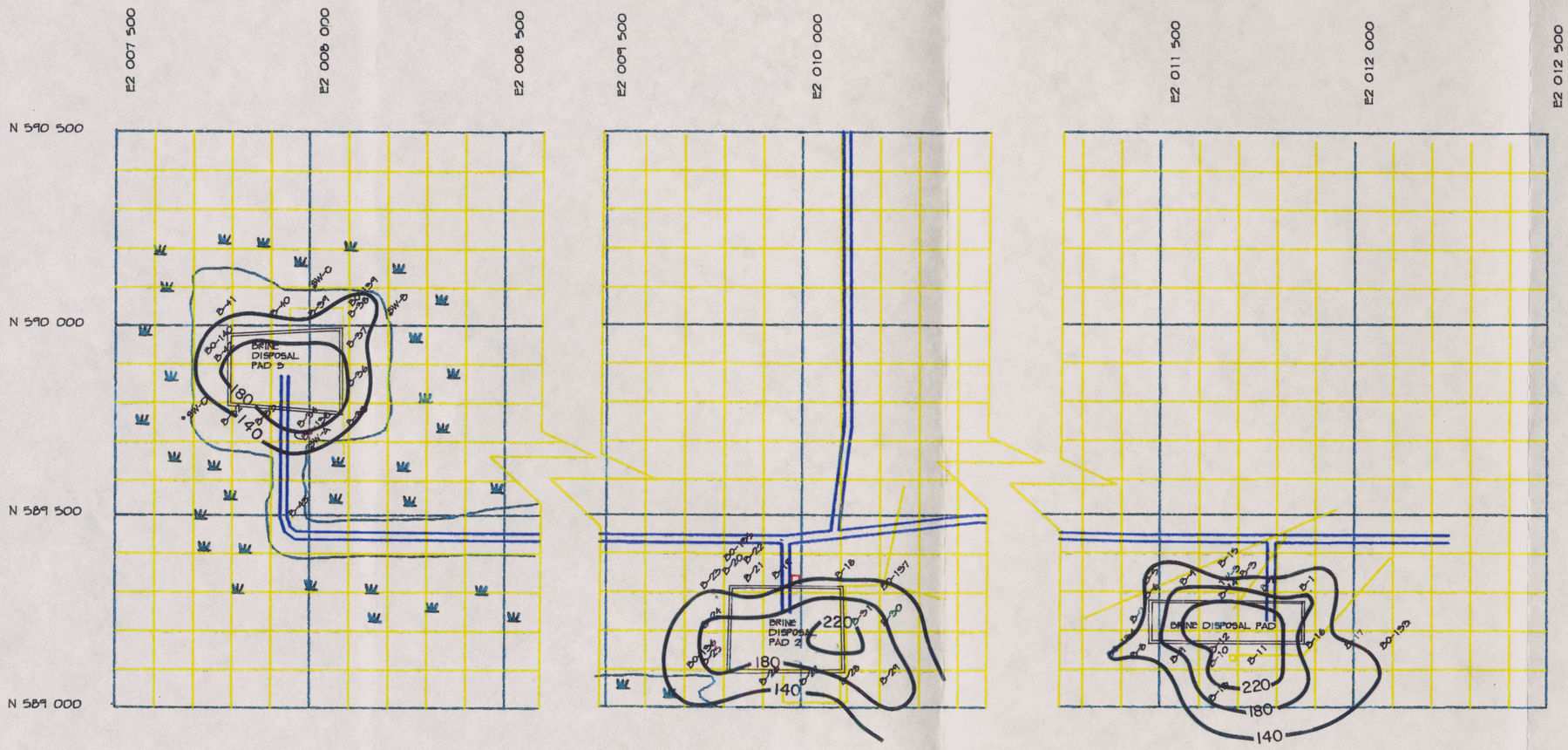


FIGURE 3.1-8
ELECTROMAGNETIC TERRAIN CONDUCTIVITY RESULTS - DEEP DEPTH OF INVESTIGATION
BAYOU CHOCTAW DISPOSAL WELL PADS
IBERVILLE PARISH, LOUISIANA
Source: ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

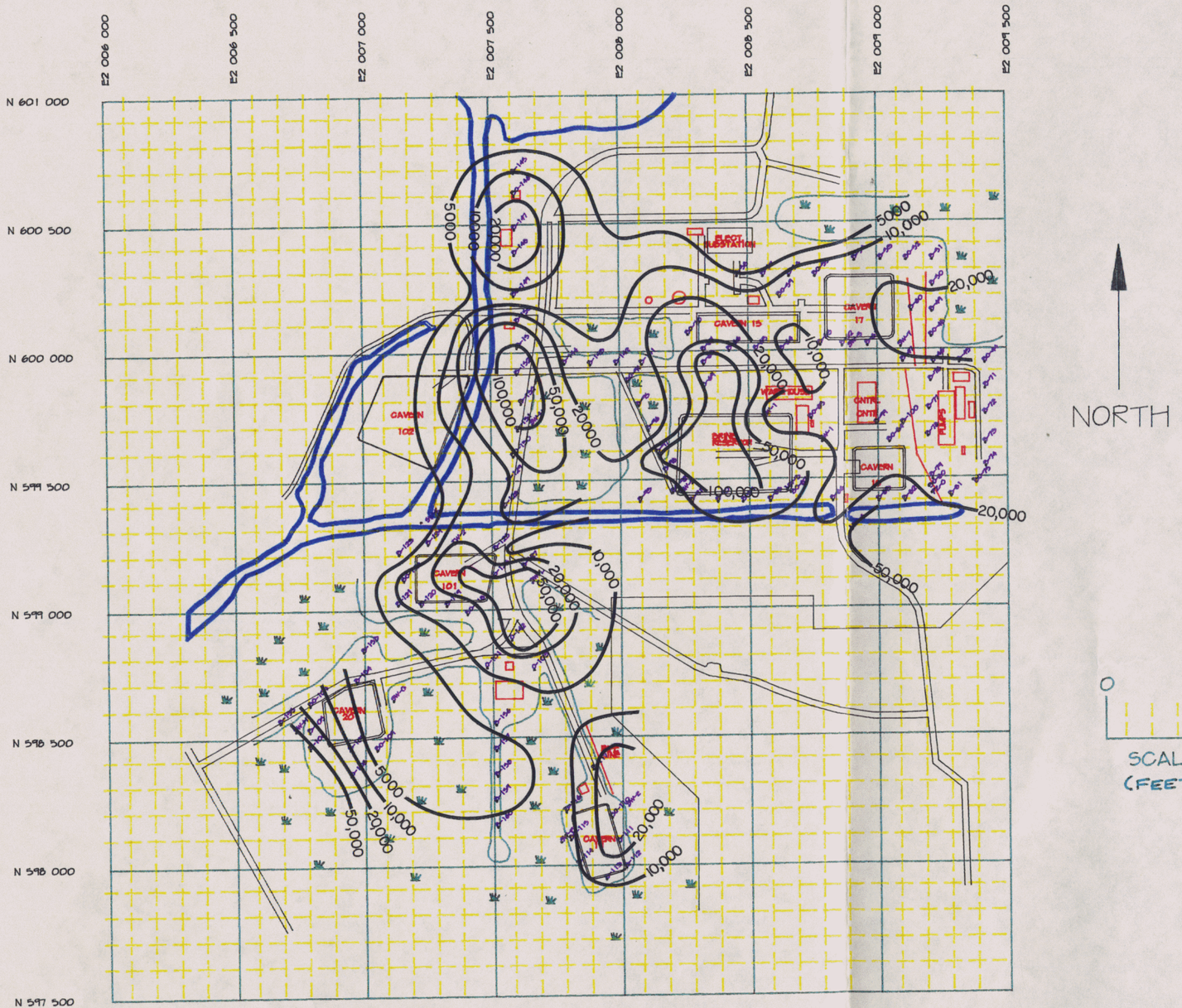


FIGURE 3.1-9
PREDICTED TOTAL DISSOLVED SOLIDS IN GROUNDWATER
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Sources: STEI, 1993; ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

Table 3.1–1 Laboratory Analtycial Results, Boeing Petroleum Services, Inc., Bayou Choctaw SPR Site

Station		Date	Sampling Interval (ft. bls)	Matrix	Analyte	Detection Limit	(units)	Analytical Result	Field Parameter	Result	(units)
BO	85	05–Nov–92	N/A	WTR	TPH	1.0	MG/L	9.0	pH	9.08	std.unit
BO	85	05–Nov–92	N/A	WTR	SALINITY	0.01	PPT	0.09	SP.COND	446.0	uS/cm
BO	85	05–Nov–92	N/A	WTR	TDS	10.0	MG/L	341	SP.COND	446.0	uS/cm
BO	133	26–Oct–92	N/A	WTR	N/A	N/A	N/A	N/A	SP.COND	2130.0	uS/cm
BO	133	26–Oct–92	N/A	WTR	N/A	N/A	N\A	N/A	pH	6.59	std.unit
BO	138	03–Nov–92	N/A	WTR	N/A	N/A	N/A	N/A	SP.COND	1885.0	uS/cm
BO	138	03–Nov–92	N/A	WTR	N/A	N/A	N\A	N/A	pH	6.62	std.unit
BO	140	03–Nov–92	N/A	WTR	N/A	N/A	N/A	N/A	SP.COND	600.0	uS/cm
BO	140	03–Nov–92	N/A	WTR	N/A	N/A	N\A	N/A	pH	8.97	std.unit
MW	1	12–Nov–92	N/A	WTR	TDS	10.0	MG/L	16100	N\A		N\A
MW	1	12–Nov–92	N/A	WTR	SALINITY	N/A	PPT	14.1	N/A		N/A
MW	2	12–Nov–92	N/A	WTR	TDS	10.0	MG/L	22200	N\A		N\A
MW	2	12–Nov–92	N/A	WTR	SALINITY	N/A	PPT	19.3	N/A		N/A
MW	3	12–Nov–92	N/A	WTR	TDS	10.0	MG/L	77400	N\A		N\A
MW	3	12–Nov–92	N/A	WTR	SALINITY	N/A	PPT	69	N/A		N/A
MW	4	12–Nov–92	N/A	WTR	TDS	10.0	MG/L	42700	N\A		N\A
MW	4	12–Nov–92	N/A	WTR	SALINITY	N/A	PPT	40.4	N/A		N/A
O	103	11–Nov–92	N/A	WTR	TDS	10.0	MG/L	6390			
O	103	02–Nov–92	N/A	WTR	SALINITY	0.01	PPT	2.06	SP.COND	7640.0	uS/cm
O	103	02–Nov–92	N/A	WTR	TPH	1.0	MG/L	12	pH	6.65	std.unit
TW	1	03–Nov–92	N/A	WTR	TDS	10.0	MG/L	27300	SP.COND	>10000.0	uS/cm
TW	1	03–Nov–92	N/A	WTR	SALINITY	0.01	PPT	29	SP.COND	>10000.0	uS/cm
TW	1	03–Nov–92	N/A	WTR	TPH	1.0	MG/L	9.8	pH	6.30	std.unit
TW	2	06–Nov–92	N/A	WTR	SALINITY	0.01	PPT	0.05	SP.COND	860.0	uS/cm
TW	2	06–Nov–92	N/A	WTR	TDS	10.0	MG/L	604	SP.COND	860.0	uS/cm
TW	2	06–Nov–92	N/A	WTR	TPH	1.0	MG/L	2.5	pH	8.32	std.unit
TW	3	29–Oct–92	N/A	WTR	SALINITY	0.01	PPT	2.66	SP.COND	5360.0	uS/cm
TW	3	29–Oct–92	N/A	WTR	TDS	10.0	MG/L	3880	pH	6.04	std.unit

TPH – TOTAL PETROLEUM HYDROCARBONS, MOD. METHOD 418.1
TDS – TOTAL DISSOLVED SOLIDS, METHOD 160.1
SALINITY – STD METHODS METHOD 2520
N/A – NOT ANALYZED

Source: ECT, 1993.

Table 3.1–2. Soil Gas Survey Results, Boeing Petroleum Services, Inc., Bayou Choctaw SPR Site

ID Station	Date	Sampling Interval (ft. bls)	Non-Filtered OVA (Total PPM)	Filtered OVA (C1–C2 Fraction PPM)	Total Non-Methane/ Ethane HC (PPM)	Purge Ratio	Comments
BO–44	03–Nov–92	2–2.3	0	0	LP	1.00	Poor Soil Gas Flow, Screened Probe Method
BO–48	03–Nov–92	0.6–0.9	0	0	ND	1.09	Fair Soil Gas Flow, Screened Probe Method
BO–52	05–Nov–92	1.7–2	0.5		ND		Screened Probe Method, Standing wtr in area
BO–55	12–Jan–93	0–5	15	17	ND	1.19	Drop Tube, ND w/open–end rod method @ 3–5 ft bls
BO–59	12–Jan–93	0–8	3.0	1.3	1.8		Drop Tube, Wtr @ 3 ft, LP w/open–end rod @ 2.5–3
BO–61	05–Nov–92	2.1–2.4	2.0		ND	1.00	Screened Probe Method, No OVA Filter
BO–65	12–Jan–93	7.5–8	1.0	0	1.0	1.09	Fair Soil Gas Flow, Open–End Rod Method, Wtr rise to surface
BO–70	12–Jan–93	0–4	4.0	0	4.0		Drop Tube, Wtr @ 4.0 ft bls, ND w/open–end rod @ 3–8 ft bls
BO–75	12–Jan–93	7.5–8	0.0	0	LP	1.00	Poor Soil Gas Flow, Open–End Rod Method
BO–77	03–Nov–92	2.1–2.4	0.5	0.5	LP	1.00	Low Perm.
BO–80	12–Jan–93	0–8	19	8.8	10.0		Drop Tube Method, Wtr @ 3.0 ft bls, Poor Gas Flow w/open–end rod
BO–84	12–Jan–93	0–2.75	10.0	0	10.0		Drop Tube Method, Anydrite at 3 ft bls
BO–85	12–Jan–93	0–2	488	248	240		Drop Tube, Wtr rise to 2 ft bls, Open–end rod of 175 ppm @ 7.5–8
BO–87	05–Nov–92	6.6–7	4.5		ND	1.09	Fair Soil Gas Flow, Screened Probe, No OVA filter
BO–92	12–Jan–93	0–5	1.5	0.5	1.0		Drop Tube Method, Wtr rise to 2.25 ft bls, LP other method
BO–94	12–Jan–93	0–5	25	18	7		Drop Tube Method, Wtr rise to 1.5 ft bls
O–101	05–Nov–92	2.6–2.9	1.0		LP	1.00	Poor Soil Gas Flow, Screened Probe Method
O–102	02–Nov–92	2.2–2.5	7.0	5.5	1.5	1.41	Fair Soil Gas Flow, Difficult probing
O–103	02–Nov–92	0.6–0.9	17	15	2	1.00	Poor Soil Gas Flow, Screened Probe, 1st hole pumped wtr
BO–104	29–Oct–92	2.1–2.4	2000	1500	500	2.00	High Soil Gas Flow, Screened probe method, Flame–out w/filter
BO–109	29–Oct–92	2.6–2.9	18	0	18	1.09	Fair Soil Gas Flow, Screened Probe Method
BO–110	02–Nov–92	0.7–1	0	0	ND	1.71	High Soil Gas Flow, Wtr @ surface
BO–115	03–Nov–92	2.3–2.5	50	30	20	1.50	High Soil Gas Flow/Rdgs max prior to flame–out/Nonstable reading
BO–118	29–Oct–92	2.6–2.9	0	0	LP	1.00	Poor Soil Gas Flow, Screened Probe Method
BO–122	29–Oct–92	2.6–2.9	4000	4000	ND	1.00	Fair to Poor Soil Gas Flow, Screened probe method
BO–130	03–Nov–92	2.6–2.9	22	27	ND	1.02	Fair Soil Gas Flow, Screened probe method
BO–138	03–Nov–92				WTR		Brine Disp Well Pad 3, Pumped wtr & no soil gas reading

Table 3.1–2. Soil Gas Survey Results, Boeing Petroleum Services, Inc., Bayou Choctaw SPR Site

ID Station	Date	Sampling Interval (ft. bls)	Non–Filtered OVA (Total PPM)	Filtered OVA (C1–C2 Fraction PPM)	Total Non–Methane/ Ethane HC (PPM)	Purge Ratio	Comments
BO–139	03–Nov–92	1.1–1.4	0.5	0.0	LP	1.00	Bring Disp. Well Pad 3, Clogged, Low Perm, No soil gas reading
BO–140	03–Nov–92	1–1.3	5.0	5.0	ND	1.00	Brine Disp. Pad 3/Sampled wtr/N2 bubbles 2 surf. upon pressurization
BO–146	05–Nov–92	2.5–2.8	2.8		WTR	1.09	Pumped Water, No OVA filter, Reading from flask headspace
BO–149	29–Oct–92	1.6–1.9	11	7.0	4	1.13	Good Soil Gas Flow, Screened Probe Method, In dry ditch
TW–2	29–Oct–92	2.6–2.9	55	100	ND	1.00	Poor Soil Gas Flow, Screen probe adj to TW2, Btm 0.5 ft probe tip wet
TW–3	28–Oct–92	3–4	11				Brine Disp Well 1, Headspace from soil interval of boring above wtr

NOTES: ND – NONE DETECTED

LP – NON–DETECTED CONCENTRATION INTERPRETED DUE TO LOW PERMEABILITY SOIL

WTR – WATER PUMPED IN SYSTEM, NO SOIL GAS SAMPLE OBTAINED

PURGE RATIO IS RATIO OF MAX. ATTAINABLE SYSTEM VACUUM PRESSURE &

SUSTAINED VACUUM PRESSURE DURING PURGING; A READING OF 1.0 CORRESPONDS

TO LOW SOIL PERMEABILITY; READINGS >1.0 INDICATE SOME GAS FLOW

Source: ECT, 1993.

Table 3.1-3 EM Terrain Conductivity Results, Bayou Choctaw SPR Site

Station I.D.	North Coord.	East Coord.	Elevation (ft.)	10 m Horiz.	10 m Vert.	20 m Horiz.	20 m Vert.	40 m Horiz.	40 m Vert.	Comments
B-1	589320	11875	10	143	38	170				
TW-1	599645	8785	12	204	33	282	40			
B-2	589318	11774	10	135	80	152	70	143		
TW-2	599245	7357	13	183	100	265	160			
B-3	589353	11722	10	148	35	148	89	250		
TW-3	589330	11667	10	158	32	153	50	90		
B-4	589331	11567	10	114	200	175				
B-5	589334	11472	10	133	105	150	5	122		
B-6	589295	11447	11	131	112	135	112			
B-7	589233	11440	10	118	79	125	55			
B-8	589140	11442	12	140	77	140	63	100	86	
B-9	589131	11545	12	143	100	151	30			Unstable meter response
B-10	589122	11643	12	200	60	240	31	170	135	
B-11	589129	11743	12	220	30	250	18			
B-12	589157	11646	12	175	58	210	40	137	70	
B-13	589032	11644	12	192	90	190	29			
B-14	589297	11667	10	165	70	210	110	141		
B-15	589380	11666	10	160	42	90				
B-16	589172	11892	11	140	75	146	120	115	112	
B-17	589172	11993	11	135	85	140	70	121	73	
B-18	589340	10102	11	138	65	142	54			
B-19	589338	9941	11	112	70	125	66			
B-20	589347	9814	11	110	73	120	71	121	110	
B-21	589330	9869	11	100	79	113	71			
B-22	589377	9868	11	102	73					No meter separation at 20m int.
B-23	589309	9757	11	141	85	141	63			
B-24	589209	9761	11	170	75	185	71	131	65	
B-25	589104	9725	11	170	84	183	39			
B-26	589063	9910	11	120	85	140	95			
B-27	589064	10013	11	135	80	145	75			Above grnd pipeline nearby
B-28	589067	10116	11	122	65	165	85			Above grnd pipeline nearby
B-29	589069	10219	11	200	70	205				
B-30	589221	10220	11	180	40	180	50	192	55	
B-31	289221	10144	11	158	70	208	75	140		
B-32	589717	7785	10	125	90			100		No meter separation at 20m int.

Table 3.1–3 EM Terrain Conductivity Results, Bayou Choctaw SPR Site

Station I.D.	North Coord.	East Coord.	Elevation (ft.)	10 m Horiz.	10 m Vert.	20 m Horiz.	20 m Vert.	40 m Horiz.	40 m Vert.	Comments
B–33	589718	7872	10	120	80	142	105			
B–35	589718	8109	10	103	91	133	100	115	72	
B–36	589821	8108	10	160	99	175	85	137	107	
B–37	589922	8107	10	148	90	167	83			
B–38	589999	8109	10	150	80	158	87	108		
B–39	589999	8007	10	132	104	146				
B–40	589998	7908	10	125	81	145	95	120	125	
B–41	590000	7771	10	141	60	145	77	135	110	
B–42	589881	7765	10	171	96	183	90			
B–43	589483	7962	10	130	75	140	66			
BO–44	599952	9418	10							No meter separation attainable
B–45	599952	9319	10	>300			>300			No meter separation at missing data
B–46	599949	9218	10	100	50					No meter separation at 20m int.
B–47	599954	9100	10	165						No meter separation at missing data
BO–48	600052	9209	10	201	31	290	40	>300		
B–49	600149	9212	10	219	30	>300	>300			
B–50	600250	9213	10	175	5	247	25			
B–51	600353	213	10	246	53	294		>300		
BO–52	600352	9112	10	290				282		No meter separation at missing data
B–53	600353	9014	10	234	70	>300				
B–54	600351	8913	10	205	55	238				
BO–55	600288	8759	10	179	100	210		190		
B–56	600287	8659	10	236	56	274	10			
B–57	600288	8558	10	235	23	263	30			
B–58	600288	8557	11	188	17	205	95			
BO–59	600206	8623	10	235	80	270				
B–60	600154	9132	10	150	40	235	85			
BO–61	600017	8963	10	174	25	>300	150			
B–62	600017	8865	10	225	30	297	20			
B–63	600019	8779	10	240	50	295	100			
B–64	599997	8632	10	260	120	240				
BO–65	599997	8530	10	290						No meter separation at missing data
B–66	599996	8428	10	121	190	185				High voltage box w/in 30 ft.
B–67	599995	8327	10	150	71	115	>300	180		
B–68	599943	8328	13	145	74	270	175			

Table 3.1-3 EM Terrain Conductivity Results, Bayou Choctaw SPR Site

Station I.D.	North Coord.	East Coord.	Elevation (ft.)	10 m Horiz.	10 m Vert.	20 m Horiz.	20 m Vert.	40 m Horiz.	40 m Vert.	Comments
B-69	599856	8329	13	171	121	256	158			
BO-70	600061	8268	10	154	61	210				Elect. Cable near
B-71	599823	9419	10	140	140	>300	>300			
B-72	599752	9420	10	>300						No meter separation at missing data
B-73	599638	9420	10	>300						No meter separation at missing data
B-74	599550	9423	10	>300						No meter separation at missing data
BO-75	599495	9370	10	240	60	270				
B-76	599821	9214	12	198	32	250	70			
BO-77	599721	9212	12	220	50	>300	190			Overhead cable tray
B-78	599617	9215	11	227	60	280				
BO-80	599470	9199	11	210	42	265	108			Elect. Cable near
B-81	599431	9287	11	280	50	>300		>300		
B-82	599413	9108	11	240	32	>300				
B-83	599413	9008	10	245	30	>300				
BO-84	599648	8940								No readings taken
BO-85	599734	8742								No readings taken
B-86	599415	8827	11	145	128	160	50	215		
BO-87	599448	8665	11	180	106	264	210			
B-88	599412	8587	11	>300	107	>300				
B-89	599411	8484	11	292	146					No meter separation at missing data
B-90	599410	8384	11	190	108					No meter separation at missing data
B-91	599409	8284	11	>300	200					No meter separation at missing data
BO-92	599446	8211	11	>300	>300		>300			
B-93	599410	8083	11	194	130	272	135			
BO-94	599870	8050	11	175	24		148			
B-95	599781	8077	11	192	13	271				
B-96	599689	8115	11	186	78	210	>300			
B-97	599597	8152	11	100	94	180	250			
B-98	599528	8181	11	184	51	273				
B-99	599711	8999	12							No meter separation
B-100	599711	9101	12	205	30					Overhead cable tray
O-101	599765	7486	15	112	52	166	65			
O-102	598873	7584	15	150	57	247	30			
O-103	598757	7669	15	182	70	210				
BO-104	598620	6800	13	190	42	248	80	191		

Table 3.1-3 EM Terrain Conductivity Results, Bayou Choctaw SPR Site

Station I.D.	North Coord.	East Coord.	Elevation (ft.)	10 m Horiz.	10 m Vert.	20 m Horiz.	20 m Vert.	40 m Horiz.	40 m Vert.	Comments
B-105	598511	6795	12	200	72	>300	187			
B-106	598445	6797	12	180	65	290	>300			
B-107	598442	6954	11	220	100	>300				
B-108	598340	6959	10	185	198	242	200			
BO-109	598442	7060	11	215	120	180				
BO-110	598182	7973	13	157	55	235				
B-111	598084	8000	11	218	25	>300				
B-112	597987	8029	10	250	55	295				
B-113	597941	7952	10	254	72	>300				
BO-115	598093	7813	10	210	170	>300				
B-116	598202	7795	10	229	92	240				
B-117	598369	7901								No readings taken
BO-118	598970	7412	15	148	70	172	112			
B-119	599002	7330	15	40	100					No meter separation at missing data
B-120	599003	7229	15		70					No meter separation at missing data
B-121	599004	7139	15	167	62	185	120			
BO-122	599098	7161	15	175	73	215	10			
B-123	599202	7142	14	130	58	127	100			
B-124	599241	7255	13	178	91	187	92			
B-25	599223	7519	14	179	109	197	206			
B-126	599119	7517	14	140	50					
B-127	599154	7630	13	180	25	290				
B-128	599388	7555	13	165	78	230	40			
B-129	599488	7571	12	201	25	270	5			
BO-130	599579	7505	12	210	30	277	70			
B-131	599686	7605	12	170	30					No meter separation at missing data
B-132	599790	7620	12	110	40	205				
BO-133	589171	12085	11	121	70	130	71			
BO-134	589142	11382	11	130	55	140	55			
BO-135	589382	9816	11	108	80					No meter separation at missing data
BO-136	589100	9716	11	182	81	173	50			
BO-137	589312	10218	11	161	93	162	73	142	40	
BO-138	589706	7969	11	132	82	148	68			
BO-139	590028	8111	10	162	90	170	79	130		
B-140	589900	7740	10							No readings taken

Table 3.1-3 EM Terrain Conductivity Results, Bayou Choctaw SPR Site

Station I.D.	North Coord.	East Coord.	Elevation (ft.)	10 m Horiz.	10 m Vert.	20 m Horiz.	20 m Vert.	40 m Horiz.	40 m Vert.	Comments
B-141	599943	8090	13	165	15	230	10			
B-142	598873	7584	13	190	40	>300				
B-143	599940	7889	13	190	12	>300				
B-144	599944	7789	13	160	15	225				
B-145										No readings taken
BO-146	600592	7593	13	128	40	170	75			
B-147	600468	7594	13	220	40	135	130			
B-148	600369	7594	13	113	206	148				
BO-149	600205	7611	9	224	68	250	51			
B-150	600105	7604	12	120	48	195	50			
B-151	600005	7614	13	105	45	195				
B-154	598706	6979	13	222	80	200		180	>300	No meter sep at missing data
B-155	598546	6680	12	154	83			170	180	No meter sep at 20m int.
B-156	598550	7528	11	200	80	210	62			
B-157	598438	7528	11	220	54	220	33			
B-158	598337	7528	11	215	20	220	46			
B-159	598237	7528	11	225	12	245	28			
B-160	598137	7528	11	188	42	212	122			
MW-1	599735	8564	13	192	27	250	40			
MW-2	599448	8232	11	>300	>300		>300			
MW-3	599456	8653	11	180	106	264	210			
MW-4	599299	8904	11	170	40	270	35			

END OF EM SURVEY DATA FOR BAYOU CHOCTAW SPR SITE

B - BRINE SURVEY STATION
BO - BRINE AND OIL SURVEY STATION
TW - TEMPORARY WELL
OW - OBSERVATION WELL
MW - MONITOR WELL

Data acquired 10/28/92 to 11/05/92 using a Geonics EM-34 terrain conductivity meter, if readings at one station were obtained using multiple receiver directions, the results were averaged or qualitatively edited if interference from surface features was suspected.

Source: ECT, 1993

Section 4.0

4.0 RECOMMENDATIONS

ECT and STEI assume that the objectives of a future verification survey will be to confirm subsurface impact by brine and/or crude oil (petroleum hydrocarbons), as predicted by screening techniques used in the Survey. Although reasonable effort should be made to identify lateral extent of impact, the initial activities in the verification survey should be limited to confirmation of such impact. A phased approach, basing additional monitor well locations on data obtained from initial confirmation wells, would be a logical and most cost-effective methodology.

In general, the proposed verification activities could be grouped into two categories: (1) those instances in which Survey results have identified generalized areas (or zones) of potential impact, where an additional limited screening survey would more properly and economically determine proper well placement and design for verification; and (2) instances in which Survey results indicate the need for specific monitor well location and design. Sites in which further screening would be beneficial to verification activities have been delineated on Figures in this section. Monitor well locations have also been arbitrarily illustrated within these zones to define the probable number of wells, and not necessarily the exact recommended locations.

In those areas in which base survey data indicates the need for monitor well installation at specific locations, we recommend that well installation first occur in the area of greatest predicted impact. Should field screening at those well samples indicate no potential problem in these areas of greatest predicted impact, additional recommended wells could be eliminated based on the presumption that anomalous areas were due to extraneous interference. Monitor well construction specifications included in the purchase contract are considered appropriate except near areas of vehicular passage, where flush-grade surface completions are recommended.

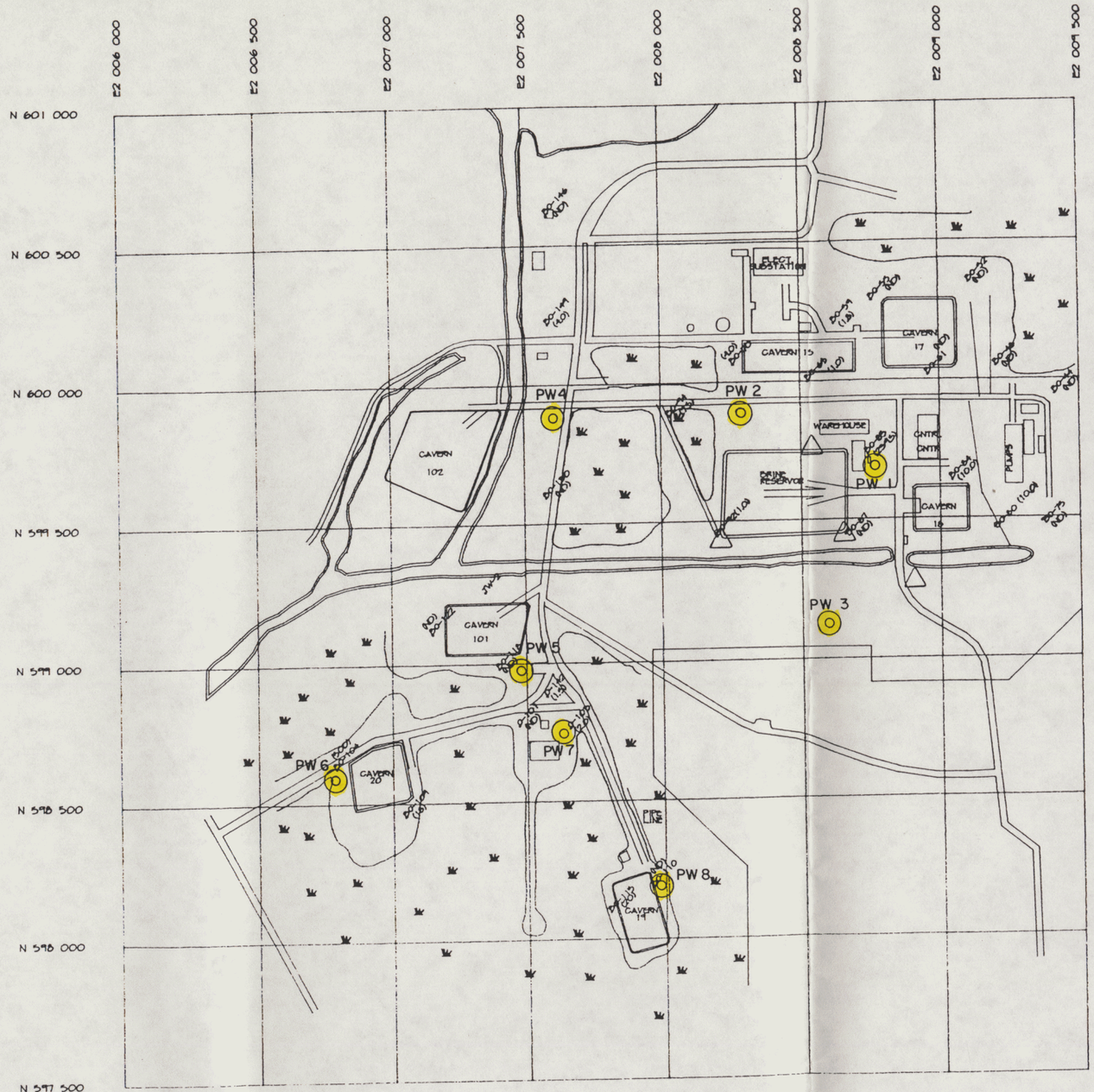
Recommendations for verification activities are briefly summarized on a site-by-site basis. Proposed monitor well locations and/or zones benefiting from further

screening activities are indicated in Figures included at the end of this section.

4.1 BAYOU CHOCTAW SPR SITE

Four monitor wells currently exist at the Bayou Choctaw site; they surround the brine pond. The shallowest significant more-permeable water-bearing sand occurs at a depth of 30 feet bls near the brine ponds. Attempting further screening activities using drive points to this depth is not considered cost effective. Figure 4.1-1 displays the location of current monitor wells, and proposed locations (PW for proposed well) for additional wells at the main site. Proposed monitor well locations at the brine disposal well pads are displayed in Figure 4.1-2. A summary of the proposed wells follows:

Proposed Well	Location/Depth	Function
PW-1	East of Brine Pond, (35 feet bls)	Brine and crude oil, EM and soil gas anomaly, elevated TDS and Salinity in existing wells
PW-2	North of Brine Pond, (35 feet bls)	Brine, EM anomaly
PW-3	South of Brine Pond, (35 feet bls)	Brine, EM anomaly
PW-4	East of Cavern 102, (35 feet bls)	Brine, EM anomaly
PW-5	Southeast of Cavern 101, (35 feet bls)	Brine, EM anomaly
PW-6	West of Cavern 20, (35 feet bls)	Brine and crude oil, EM and soil gas anomaly
PW-7	East of USTs, (25 feet bls)	Petroleum fuels, TPH detected in groundwater sample
PW-8	East of Cavern 19, (35 feet bls)	Brine, EM anomaly at wellhead
PW-9	Brine Disposal Well No. 1, (35 feet bls)	Brine, EM anomaly at wellhead
PW-10	Brine Disposal Well No. 2, (35 feet bls)	Brine, EM anomaly at wellhead
PW-11	Brine Disposal Well No. 3, (35 feet bls)	Brine, EM anomaly at wellhead



△ EXISTING MONITOR WELL

◎ PROPOSED MONITOR WELL LOCATION

0 500

SCALE (FEET)

NORTH

FIGURE 4.1-1
PROPOSED VERIFICATION SURVEY LOCATIONS
BAYOU CHOCTAW SPR SITE
IBERVILLE PARISH, LOUISIANA
Source: STEI, 1993; ECT, 1993.

ECT
Environmental Consulting & Technology, Inc.

FIGURE 4.1-2
PROPOSED VERIFICATION SURVEY LOCATIONS
BAYOU CHOCTAW BRINE DISPOSAL WELL PADS
IBERVILLE PARISH, LOUISIANA
Source: STEI, 1993; ECT, 1993.

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Appendix A

LOG OF BORING

Sheet 1 of 1

Client: **BOEING PETROLEUM SERVICES**
Location: Bayou Choctaw SPR
Project No.: 92529-2101
First Encountered Water: 4.5 ft.
Total Depth: 6.0 ft.

Boring Number: **TW-1**
Drilled by: M. Calamia, B. Groves
Logged by: B. Groves
Surf. Elev.:
Date Completed: 11/02/92

DESCRIPTION	DEPTH (ft bls)	OVA (ppm)	WATER LEVEL	SAMPLE REC.	SYMBOL	WELL DESIGN
0.0'-2.0' Sandy clay, stiff, brown, mottled with 1/4"-3/4" anhydrite layers.	0	NM	▽			
	2	NM	11/03/92			
		NM				
2.0'-6.0' Clay, very stiff, gray, very sticky, water saturated at 4.5 ft.	4	NM	▽ 11/02/92			
	6	NM				
	8					
	10					
	12					
	14					
	16					

Notes: Boring drilled with hand-operated power auger. Open hole temporary well completion 11/02/92. Sampled boring grouted full depth 11/03/92. NM: OVA readings not measured.

Clay, Silt, Silty Clay, Sandy Silt, Sand, Gravel

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Environmental Consulting & Technology, Inc.

LOG OF BORING

Client: **BOEING PETROLEUM SERVICES**
Location: Bayou Choctaw SPR
Project No.: 92529-2101
First Encountered Water: 2.0 ft.
Total Depth: 3.0 ft.

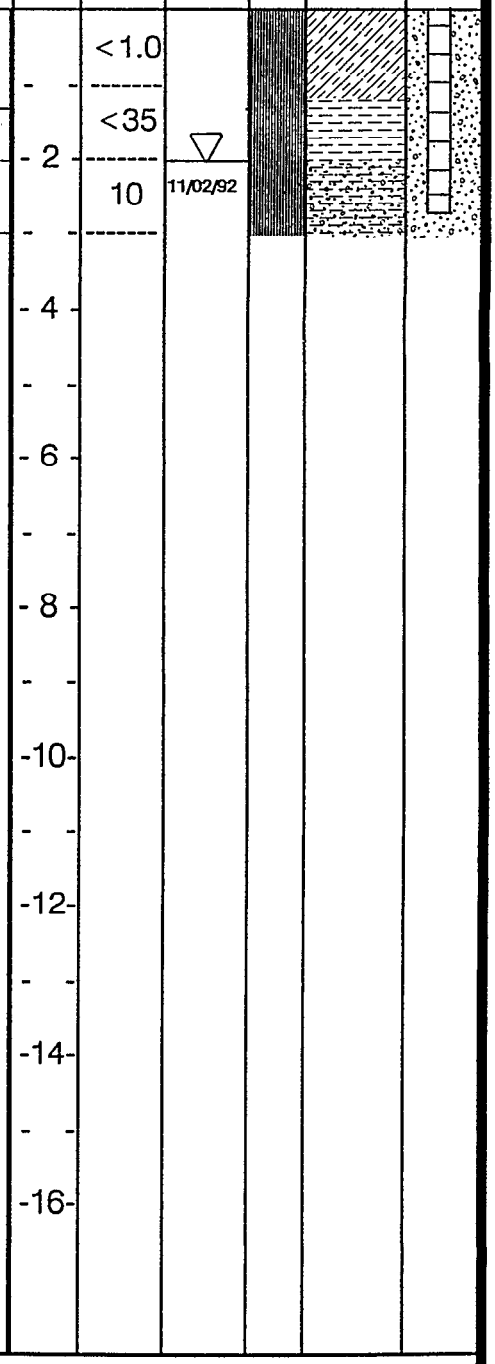
Boring Number: **TW-2**
Drilled by: M. Calamia, B. Groves (Hand Augered)
Logged by: G. Miller
Surf. Elev.:
Date Completed: 11/02/92

DESCRIPTION

0.0'-1.3' Silty Loam, soft, crumbly, brown with rust colored mottles (grades into gray sandy clay, heavily mottled at 1.0'-1.3').

1.3'-2.0' Clay, medium, cohesive, uniform gray (with gravel, and saturated at 2.0 ft.)

2.0'-3.0' Clayey, gravel, non-cohesive, water saturated and flowing into borehole.



Notes: Placed 2" diam. temporary well in boring 11/02/92. Sampled, pulled well, and grouted full depth 11/06/92. OVA readings of total hydrocarbons (including methane/ethane) with background subtracted.

Clay | Silt | Silty Clay | Sandy Silt | Sand | Gravel

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Environmental Consulting & Technology, Inc.

LOG OF BORING

Client: **BOEING PETROLEUM SERVICES**
Location: Bayou Choctaw SPR
Project No.: 92529-2101
First Encountered Water: 4.0 ft.
Total Depth: 5.5 ft.

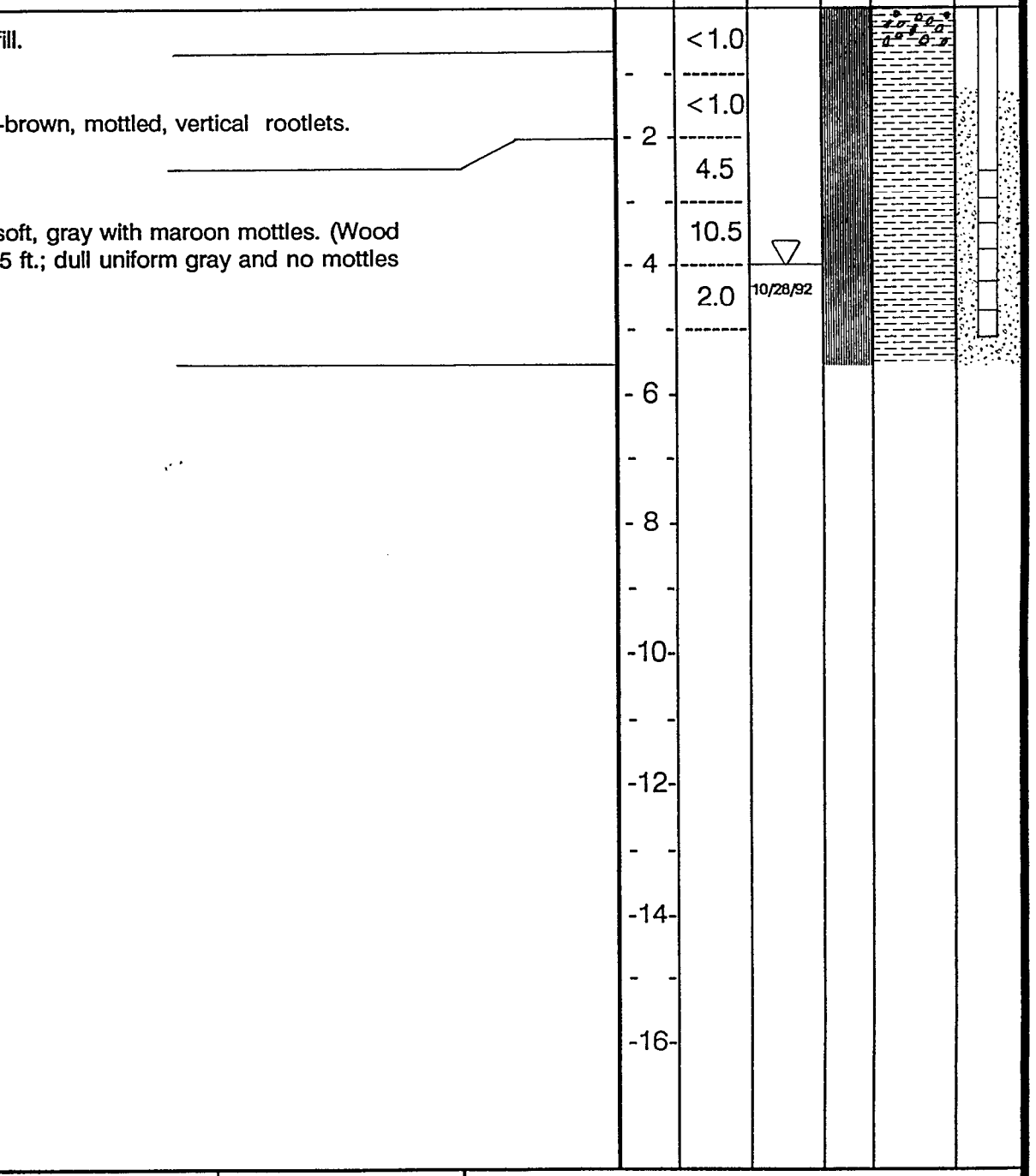
Boring Number: **TW-3**
Drilled by: G. Miller (Hand Augered)
Logged by: G. Miller
Surf. Elev.:
Date Completed: 10/28/92

DESCRIPTION

0.0'-0.6' Clay and rock fill.

0.6'-2.0' Clay, stiff, gray-brown, mottled, vertical rootlets.

2.0'-5.5' Clay, medium soft, gray with maroon mottles. (Wood fragments at 3.5 ft.; dull uniform gray and no mottles at 4.0-5.5 ft.)



Notes: Placed 2" diam. temporary well in boring 10/28/92. Sampled, pulled well, and grouted full depth 10/29/92. OVA readings of total hydrocarbons (including methane/ethane) with background subtracted.

Clay | Silt | Silty Clay | Sandy Silt | Sand | Gravel

ECT
Environmental Consulting & Technology, Inc.

Appendix B

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

INVOICE COPY

Certificate of Analysis No. W1118611

ENVIRONMENTAL CONSULTING & TECHNOLOGY
10988 N. HARRELL'S FERRY, SUITE 12
BATON ROUGE, LA 70812

GREG MILLER 12-18-92

Location:	BOEING / MONITORING WELLS (GROUNDWATER SURVEY)
Field:	TASK #2100 - BAYOU CHOCTAW PLAQUEMINE, LA
Sample of:	WATER
Sample point:	8925 - MW1
Sampled by:	BOEING
Sample Date:	11-12-92, 11:30 AM

		Results	Detection Limit	
TAL DISSOLVED SOLIDS	* Method 160.1	16100	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-18-92, 04:30 PM				
LINITY @ 25 DEG.C.	* Method 2520C	14.1	NA	ppt
Analyzed by: J. DURAND				
Date & Time: 12-16-92, 03:00PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. W1118612

ENVIRONMENTAL CONSULTING & TECHNOLOGY
10988 N. HARRELL'S FERRY, SUITE 12
BATON ROUGE, LA 70812

GREG MILLER 12-18-92

Location:	BOEING / MONITORING WELLS (GROUNDWATER SURVEY)
Field:	TASK #2100 - BAYOU CHOCTAW PLAQUEMINE, LA
Sample of:	WATER
Sample point:	8926 - MW2
Sampled by:	BOEING
Sample Date:	11-12-92, 11:16 AM

		Results	Detection Limit	
TDL DISSOLVED SOLIDS	* Method 160.1	22200	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-18-92, 04:30 PM				
LINITY @ 25 DEG.C.	* Method 2520C	19.3	NA	ppt
Analyzed by: J. DURAND				
Date & Time: 12-16-92, 03:00PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

C. A. Guardia

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SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. W1118613

ENVIRONMENTAL CONSULTING & TECHNOLOGY
10988 N. HARRELL'S FERRY, SUITE 12
BATON ROUGE, LA 70812

GREG MILLER 12-18-92

Location:	BOEING / MONITORING WELLS (GROUNDWATER SURVEY)
Field:	TASK #2100 - BAYOU CHOCTAW PLAQUEMINE, LA
Sample of:	WATER
Sample point:	8927 - MW3
Sampled by:	BOEING
Sample Date:	11-12-92, 11:02 AM

		Results	Detection Limit	
TOTAL DISSOLVED SOLIDS	* Method 160.1	77400	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-18-92, 04:30 PM				
SALINITY @ 25 DEG.C.	* Method 2520C	69.0	NA	ppt
Analyzed by: J. DURAND				
Date & Time: 12-16-92, 03:00PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

C. A. Guardia

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500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. W1118614

ENVIRONMENTAL CONSULTING & TECHNOLOGY
10988 N. HARRELL'S FERRY, SUITE 12
BATON ROUGE, LA 70812

GREG MILLER 12-18-92

Location:	BOEING / MONITORING WELLS (GROUNDWATER SURVEY)
Field:	TASK #2100 - BAYOU CHOCTAW PLAQUEMINE, LA
Sample of:	WATER
Sample point:	8928 - MW4
Sampled by:	BOEING
Sample Date:	11-12-92, 10:48 AM

		Results	Detection Limit	
TOTAL DISSOLVED SOLIDS	* Method 160.1	42700	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-18-92, 04:30 PM				
SALINITY @ 25 DEG.C.	* Method 2520C	40.4	NA	ppt
Analyzed by: J. DURAND				
Date & Time: 12-16-92, 03:00PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

** SPL QUALITY CONTROL REPORT **

Matrix: WATER

Reported on: 12-01-92
Analyzed on: 11-18-92
Analyst: K. JOHNSON

This sample was randomly selected for use in the SPL quality control program. The results are as follows:

TOTAL DISSOLVED SOLIDS
Method- 160.1

DUPLICATE ANALYSIS --

Sample ID	Original Sample Concentration mg/l	Duplicate Sample mg/l	% RPD #
W1118611	16100.00	16100.00	0.0

SAMPLES IN BATCH: W1118611-614, W1119622

SPL, Incorporated

John Durand

John Durand, QC Officer

BOEING PETROLEUM SERVICES
STRATEGIC PETROLEUM RES.
U.S. Dept. of Energy
BAYOU CHOCTAW, PLAQUEMINES, LA.

SPR

CHAIN OF CUSTODY RECORD

Task # 2100

SHEET NO. 9102

SITE BAYOU CHOCTAW

DATE 11/12/92

SURVEY: BOEING/MONITORING WELLS (GROUND WATER SURVEY)

SAMPLER'S SIGNATURE: Allen R. Lamm

PURCHASE ORDER NO.

CUSTODY SAMPLE NUMBER	SAMPLE STATION NUMBER	DATE	TIME	SAMPLE TYPE: WATER	SAMPLE TYPE: BRINE	SAMPLE TYPE: OTHER	NUMBER OF CONTAINERS	ANALYSIS REQUIRED
8925	MW1	11/12/92	11:30	✓			1	SALINITY, ~~CONDUCTIVITY~~ GWM, ~~TDS~~ GWM TDS
8926	MW2	11/12	11:16	✓			1	" "
8927	MW3	11/12	11:02	✓			1	" "
8928	MW4	11/12	10:48	✓			1	" "

12/2/92 As per greg miller/ECT, add Specific Conductance to test on all four samples. K. Estelle

Analyze each for SALINITY AND TDS

11/24/92
As per Bryan Groves ECT:

Send Reports + Invoice to
Environmental Consulting + Technology
10988 N. Harrell's Ferry, Ste 12
Baton Rouge, LA 70812
504-273-0444
ATTN: Greg Miller

RELINQUISHED BY: Allen R. Lamm	RECEIVED BY: Gregory W Miller	DATE AND TIME: 11-16-92 / 14:20
RELINQUISHED BY: Gregory W Miller	RECEIVED BY: James D. Lamb	DATE AND TIME: 11-17-92 / 8:00
DISPATCHED BY: James D. Lamb	RECEIVED FOR LABORATORY BY: M. Carpenter 4°C	DATE AND TIME: 11/17/92 7:20pm

METHOD OF SHIPMENT: POV

DISTRIBUTION: WHITE: ACCOMPANY SAMPLE
CANARY: SITE ENVIRONMENTAL SPECIALIST

DSF82-0159 4/82 REV. 11/87

ECT

Environmental Consulting & Technology, Inc.
(Louisiana)

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. X1109567

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-18-92

Location:	PROJECT 92-529-2101
Field:	BPS-BAYOU CHOCTAW - SPR SITE
Sample of:	WATER
Sample point:	TW3
Sampled by:	ECT
Sample Date:	10-29-92, 09:30 AM

		Results	Detection Limit	
AL DISSOLVED SOLIDS	* Method 160.1	3880	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-09-92, 10:30 AM				
INITY	** Method 2520	2.66	0.01	g/kg
Analyzed by: K. JOHNSON				
Date & Time: 11-16-92, 03:30 PM				

= Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Ron Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. X1109568

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-17-92

Project No:	92-529-2101
Project:	BPS-BAYOU CHOCTAW
Site:	BAYOU CHOCTAW SPR SITE
Sample No:	0-103
Sample of:	WATER
Sampled by:	ECT
Sample Date:	11-02-92, 10:00 AM
Date Received:	11-06-92

A N A L Y T I C A L R E S U L T S

PARAMETER	RESULTS	PQL*
Total Petroleum Hydrocarbons Method- 418.1 [EPA Wtr&Wst]	12 mg/l	1.0 mg/l

TPH ANALYZED BY : E. FAWVOR DATE/TIME: 11-16-92, 11:30 AM
TPH EXTRACTED BY : E. FAWVOR DATE/TIME: 11-16-92, 11:00 AM

Notes: * Practical Quantitation Limit
ND = Not Detected. NA = Not Analyzed.

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Ron Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. X1109568

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-18-92

Location:	PROJECT 92-529-2101
Field:	BPS-BAYOU CHOCTAW - SPR SITE
Sample of:	WATER
Sample point:	0-103
Sampled by:	ECT
Sample Date:	11-02-93, 10:00 AM

		Results	Detection Limit	
AL DISSOLVED SOLIDS	* Method 160.1	6390	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-09-92, 10:30 AM				
INITY	** Method 2520	2.06	0.01	g/kg
Analyzed by: K. JOHNSON				
Date & Time: 11-16-92, 03:30 PM				

= Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Ron Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. X1109569

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-17-92

Project No:	92-529-2101
Project:	BPS-BAYOU CHOCTAW
Site:	BAYOU CHOCTAW SPR SITE
Sample No:	TW-1
Sample of:	WATER
Sampled by:	ECT
Sample Date:	11-03-92, 10:55 AM
Date Received:	11-06-92

A N A L Y T I C A L R E S U L T S

PARAMETER	RESULTS	PQL*
Total Petroleum Hydrocarbons Method- 418.1 [EPA Wtr&Wst]	9.8 mg/l	1.0 mg/l

TPH ANALYZED BY : E. FAWVOR DATE/TIME: 11-16-92, 11:30 AM
TPH EXTRACTED BY : E. FAWVOR DATE/TIME: 11-16-92, 11:00 AM

Notes: * Practical Quantitation Limit
ND = Not Detected. NA = Not Analyzed.

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Lon Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
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Certificate of Analysis No. X1109569

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-18-92.

Location:	PROJECT 92-529-2101
Field:	BPS-BAYOU CHOCTAW - SPR SITE
Sample of:	WATER
Sample point:	TW-1
Sampled by:	ECT
Sample Date:	11-03-92, 10:55 AM

		Results	Detection Limit
TOTAL DISSOLVED SOLIDS	* Method 160.1	27300	10.0 mg/l
Analyzed by: K. JOHNSON			
Date & Time: 11-09-92, 10:30 AM			
SALINITY	** Method 2520	28.6	0.01 g/kg
Analyzed by: K. JOHNSON			
Date & Time: 11-16-92, 03:30 PM			

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
** Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Ron Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
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Certificate of Analysis No. X1109570

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-17-92

Project No:	92-529-2101
Project:	BPS-BAYOU CHOCTAW
Site:	BAYOU CHOCTAW SPR SITE
Sample No:	BO-85
Sample of:	WATER
Sampled by:	ECT
Sample Date:	11-05-92, 11:20 AM
Date Received:	11-06-92

A N A L Y T I C A L R E S U L T S

PARAMETER	RESULTS	PQL*
Total Petroleum Hydrocarbons Method- 418.1 [EPA Wtr&Wst]	9.0 mg/l	1.0 mg/l

TPH ANALYZED BY : E. FAWVOR DATE/TIME: 11-13-92, 10:30 AM
TPH EXTRACTED BY : E. FAWVOR DATE/TIME: 11-13-92, 08:00 AM

Notes: * Practical Quantitation Limit
ND = Not Detected. NA = Not Analyzed.

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Lon Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
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PHONE: (318) 237-4775

Certificate of Analysis No. X1109570

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-18-92.

Location:	PROJECT 92-529-2101
Field:	BPS-BAYOU CHOCTAW - SPR SITE
Sample of:	WATER
Sample point:	BO-85
Sampled by:	ECT
Sample Date:	11-05-92, 11:20 AM

		Results	Detection Limit	
TOTAL DISSOLVED SOLIDS	* Method 160.1	341	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-09-92, 10:30 AM				
SALINITY	** Method 2520	0.085	0.01	g/kg
Analyzed by: K. JOHNSON				
Date & Time: 11-16-92, 03:30 PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Ron Benjamin for
C. A. Guardia

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Certificate of Analysis No. X1109571

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-17-92

Project No:	92-529-2101
Project:	BPS-BAYOU CHOCTAW
Site:	BAYOU CHOCTAW SPR SITE
Sample No:	TW2
Sample of:	WATER
Sampled by:	ECT
Sample Date:	11-06-92, 10:35 AM
Date Received:	11-06-92

A N A L Y T I C A L R E S U L T S

PARAMETER	RESULTS	PQL*
Total Petroleum Hydrocarbons Method- 418.1 [EPA Wtr&Wst]	2.5 mg/l	1.0 mg/l

TPH ANALYZED BY : E. FAWVOR DATE/TIME: 11-13-92, 10:30 AM
TPH EXTRACTED BY : E. FAWVOR DATE/TIME: 11-13-92, 08:00 AM

Notes: * Practical Quantitation Limit
ND = Not Detected. NA = Not Analyzed.

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

Lon Benjamin for
C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
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ZIP 70583-8544
PHONE: (318) 237-4775

Certificate of Analysis No. X1109571

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
10988 N. HARRELL'S FERRY ROAD
SUITE 12
BATON ROUGE, LA 70816

11-18-92.

Location:	PROJECT 92-529-2101
Field:	BPS-BAYOU CHOCTAW - SPR SITE
Sample of:	WATER
Sample point:	TW2
Sampled by:	ECT
Sample Date:	11-06-92, 10:35 AM

		Results	Detection Limit	
TOTAL DISSOLVED SOLIDS	* Method 160.1	604	10.0	mg/l
Analyzed by: K. JOHNSON				
Date & Time: 11-09-92, 10:30 AM				
SALINITY	** Method 2520	0.048	0.01	g/kg
Analyzed by: K. JOHNSON				
Date & Time: 11-16-92, 03:30 PM				

D = Parameter analyzed for but not detected. The reported limit is the minimum attainable detection limit for the sample.

* Ref: Methods for Chemical Analysis of Water and Wastes, 3rd ed., EPA
* Ref: Standard Methods for Examination of Water & Wastewater, 17th ed.
* Ref: Test Methods for Evaluating Solid Waste, EPA SW846, 1986

QUALITY ASSURANCE: This analysis was performed in accordance with EPA guidelines for analysis and quality control.

SPL, Incorporated

for Benjamin Jr

C. A. Guardia

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

** SPL QUALITY CONTROL REPORT **

Matrix: Water

Reported on: 11/16/92
Analyzed on: 11/13/92
Analyst: EF

This sample was randomly selected for use in the SPL quality control program. Samples chosen are fortified with a known concentration in duplicate. The results are as follows:

Total Petroleum Hydrocarbons
Method - 418.1

SPL Sample ID Number	Blank Value mg/l	Amt Added mg/l	Matrix Spike Recovery %	Matrix Spike Duplicate Recovery %	Relative Percent Difference %
DI WATER	ND	100	92	103	11

IRW1921113103003-111692F

SPL, Incorporated

John Durand

John Durand, Corporate QC Officer

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500 AMBASSADOR CAFFERY PKWY.
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** SPL QUALITY CONTROL REPORT **

Matrix: Water

Reported on: 11/16/92
Analyzed on: 11/13/92
Analyst: EF

This sample was randomly selected for use in the SPL quality control program. Samples chosen are fortified with a known concentration in duplicate. The results are as follows:

Total Petroleum Hydrocarbons
Method - 418.1

SPL Sample ID Number	Blank Value mg/l	Amt Added mg/l	Matrix Spike Recovery %	Matrix Spike Duplicate Recovery %	Relative Percent Difference %
D[illegible] WATER	ND	100	91	97	6.4

IRW1921113110000-111692B

SPL, Incorporated

John Durand

John Durand, Corporate QC Officer

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ZIP 70583-8544
PHONE: (318) 237-4775

** SPL QUALITY CONTROL REPORT **

Matrix: WATER

Reported on: 11-18-92
Analyzed on: 11-16-92
Analyst: K. JOHNSON

This sample was randomly selected for use in the SPL quality control program. The results are as follows:

SALINITY
Method- 2520

DUPLICATE ANALYSIS --

Sample ID	Original Sample Concentration g/kg	Duplicate Sample g/kg	% RPD #
X1109571	0.04	0.04	0.0

SAMPLES IN BATCH: X1109567-571

SPL, Incorporated

John Durand

John Durand, QC Officer

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

** SPL QUALITY CONTROL REPORT **

Matrix: WATER

Reported on: 11-18-92
Analyzed on: 11-09-92
Analyst: K. JOHNSON

This sample was randomly selected for use in the SPL quality control program. The results are as follows:

TOTAL DISSOLVED SOLIDS
Method- 160.1

DUPLICATE ANALYSIS --

Sample ID	Original Sample Concentration mg/l	Duplicate Sample mg/l	% RPD #
W1104492	494.00	490.00	0.8

SAMPLES IN BATCH: W1104492, X1109567-571

SPL, Incorporated

John Durand

John Durand, QC Officer

LAFAYETTE AREA LAB
500 AMBASSADOR CAFFERY PKWY.
SCOTT, LOUISIANA
ZIP 70583-8544
PHONE: (318) 237-4775

** SPL QUALITY CONTROL REPORT **

Matrix: Water

Reported on: 11/18/92
Analyzed on: 11/13/92
Analyst: EF

This sample was randomly selected for use in the SPL quality control program. Samples chosen are fortified with a known concentration in duplicate. The results are as follows:

Total Petroleum Hydrocarbons
Method - 418.1

SPL Sample ID Number	Blank Value mg/l	Amt Added mg/l	Matrix Spike Recovery %	Matrix Spike Duplicate Recovery %	Relative Percent Difference %
DI WATER	ND	100	93	103	10

IRW1921113080000-111892G

SPL, Incorporated

John Durand

John Durand, Corporate QC Officer

CHAIN OF CUSTODY

Page __ of __

Project: Name BPS-BAYOU CHOCTAW

Number 92-529-2101

Location: BAYOU CHOCTAW SPR Site

ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
(Louisiana) (ECT)
10988 N. Harrell's Ferry Road, Ste. 12
Baton Rouge, Louisiana 70816
Phone: (504) 273-0444
FAX: (504) 273-0484

P. O. Box 40762
Baton Rouge, Louisiana 70835

SAMPLE NO.	SAMPLE MATRIX (e.g. SOIL, WATER)	COLLECTED TIME/DATE	COLLECTED FROM	COLLECTED BY	ANALYSES TO BE CONDUCTED	OTHER SPECIFICS 11/16
TW3	WATER	10-29-92 / 9:30 AM	TW3	GWM	Salinity, TDS	EF, KJ
O-103 ✓	WATER	11-2-92 / 10:00 AM	O-103	GWM	Salinity, TDS, TPH*	*No preservative on TPH EF, KJ * RB, MM
TW-1 ✓	WATER	11-3-92 / 10:55 AM	TW-1	BSG	TDS, Salinity, TPH*	* No preservative on TPH EF KJ * RB, MM
BO-85 ✓	WATER	11-5-92 / 11:20 AM	BO-85	GWM	TDS, Salinity, TPH	TDS, SALINITY IN 4oz JAR EF, KJ * RB, MM
TW2	WATER	11-6-92 / 10:35 AM	TW 2	MRD	TDS, Salinity, TPH	ONLY ½ JAR CAPACITY AVAILABLE FROM WELL note: DL = 2 TPH

Initial Custodian (ECT) Relinquished — 11/6/92 16:48 — Time & Date

James D. Rambie ECT — 11/6/92 16:48 — Received by (Company) Time & Date

Relinquished by (Company) — 19:22 / 11/6/92 — Time & Date

Rod Boyce SPL — 11/6/92 19:20 — Received by (Company) Time & Date

Relinquished by (Company) — Time & Date

Received by (Company) — Time & Date

Comments: TPH by 418.1

Salinity (2520.B AND 2520.C)

ECT

Environmental Consulting & Technology, Inc.
(Louisiana)

Appendix C

REFERENCES

Boutwell, G.P.; Lawrence, T.A.. Electromagnetic Data Interpretation Using a Multivariate Least-Square Regression: Proceedings of the FOCUS Conference on Eastern Regional Groundwater Issues; 1988 September 27 - 29; Stamford, Connecticut: National Water Well Association; 1988, p. 3- 20.

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