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ESSO TUTU SERVICE STATION

SOIL GAS VAPOR SCREENING SURVEY REPORT

ST. THOMAS, U.S.V.I.

JUNE 14, 1988

PREPARED FOR

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

1.0 PROJECT SUMMARY

On June 8, 1987, the reporting of the presence of chemicals in one of the water wells in the Tutu area of St. Thomas, US Virgin Islands (USVI) prompted the Department of Planning and Natural Resources (DPNR) of the USVI and the US Environmental Protection Agency Region II to conduct a sampling investigation of all the production wells in the area. Sample analyses revealed the presence of chlorinated & aromatic hydrocarbons, among other chemicals, in the water of some of the Tutu area wells. The highest concentration of dissolved volatile organic compounds was reported to be found at the Tillet Garden well located approx. 300 ft. upgradient from the Esso Tutu Service Station (ETSS).

Because of the reported presence of aromatic hydrocarbons, DPNR/EPA issued Administrative Orders to two of the service stations in operation in the immediate vicinity (eg. Esso and Texaco). This administrative order required the preparation and submittal of a Work Plan designed to investigate possible product releases.

In September, 1987, Esso Standard Oil S.A. Ltd. (ESSO) retained Belgodere & Associates, Inc. (BAI) to prepare the required soil vapor sampling plan for the Esso Tutu Service Station. After on-site evaluations and discussions between DPNR/EPA, CDM-Federal Programs Corporation (CDM-FPC, EPA's Contractor), BAI and ESSO, the Work Plan for this investigation was drafted and approved on March 17, 1988. On April 5, 1988

BAI personnel began the soil vapor screening survey for benzene, toluene, ethylbenzene and xylenes (BTEX). The initial screening investigation was completed on April 23, 1988.

The survey results show an area of petroleum hydrocarbon vapor concentrations with levels ranging from not detectable (ND) to 1,675 ppm of benzene in the south and central portion of the ETSS facility. Immediately to the south of the ETSS property the vapor concentrations were significantly reduced. A second area of petroleum hydrocarbon vapor concentrations ranging from ND to 128 ppm of benzene was obtained offsite in an area adjacent to the west and southwest of the station. A third area of petroleum hydrocarbon vapor concentrations ranging from ND to 2.5 ppm of benzene was found throughout the remaining sampling stations.

Although chlorinated compounds are not associated with motor fuel storage and dispensing operations, DPNR-EPA requested ESSO to include in the soil vapor screening survey analyses of the following chlorinated hydrocarbons: dichloroethylene (DCE), tetrachloroethylene (PCE), trichloroethylene (TCE). This request was made by the agencies because chlorinated compounds were reported in the groundwater and found in a previous soil vapor survey conducted in the area. This investigation showed that chlorinated hydrocarbon vapors were present in most of the points sampled.

A soil vapor survey was conducted at the Texaco service station. The Texaco service station is located 600 ft. upgradient from the ETSS facility. A report of their finding was submitted on December 18, 1987, to the regulatory agencies.

2.0 PROJECT BACKGROUND

A number of water wells have been shut down by the Department of Planning and Natural Resources of the USVI (DPNR) and the Environmental Protection Agency Region II, New York (EPA) as a result of reported groundwater contamination in the Tutu area of St. Thomas, USVI. DPNR/EPA believe that among the possible sources of aromatic hydrocarbons found in the groundwater may be the gasoline stations which operate or had operated in the Tutu area. Esso, as the owner of a gasoline service station located in the Four Winds Shopping Center at the Tutu Area of St. Thomas, was issued an administrative order by DPNR to investigate the site. Esso contracted BAI to conduct the investigation and to issue a report on the findings.

ESSO and BAI representatives met several times with EPA's Project Managers, Mr. Charles Dolan, who was subsequently replaced by Ms. Caroline Kwan; DPNR's representatives, Ms. Francine Lang and Gregory Rhymer; and the Project Officer from Camp, Dresser & McKee Federal Programs Corporation (CDM-FPC), Mr. Scott B. Graber, to discuss the technical approach to be used in the investigation.

The initial proposed work plan submitted by ESSO to DPNR-EPA in September 1987 included drilling, collection and analyses of soil samples, installation of monitoring wells and the collection and analyses of groundwater samples.

DPNR-EPA rejected ESSO's original proposed investigation plan and suggested that a soil vapor screening survey be performed. ESSO presumes that the findings of the soil vapor survey conducted at the ETSS site will be compared to the results of the soil vapor survey previously conducted to the north around the Texaco facility.

A second work plan was submitted and reviewed by DPNR/EPA. Approval of the plan was obtained on March 17, 1988. The soil vapor screening survey started on April 5 with DPNR/EPA understanding of the project limitations caused by the unavailability of low end BTEX standards of 1, 10, 100 ppb.

2.1 LOCATION AND PURPOSE OF STUDY

The Esso Tutu service station is located in St. Thomas USVI on the west side of road No. 38 in the Tutu area, at the south eastern corner of the Four Winds Shopping Center parking lot (see figure 2.1.1). Nearby facilities include a Texaco gasoline station (600' NNE), the LAGA building (formerly a clothing manufacturing plant, 875' NE), the Four Winds Shopping Center (75' W), Vitelco building (local telephone company, 100' E), Mike's Paint Store (250' ENE) and a private Lutheran school (400' S) (see figure 2.1.2).

From April 5 through 23, 1988, BAI personnel conducted a soil vapor screening survey in and around the Esso Tutu Service Station. The purpose of the soil vapor screening survey was to determine the presence and areal extent of hydrocarbon vapors in the soil matrix. It should be pointed out that soil vapor values cannot be directly equated to concentrations of dissolved hydrocarbons in the ground water.

2.2 HYDROGEOLOGICAL SETTING

According to information obtained from "Soil Survey of the U.S. Virgin Islands, 1970 Soil Conservation Service Report", issued in August 1970, the area is described as a network of terraces and alluvial fans sloping gently to moderately toward the south. Soil deposits consist of stratified sands, gravels

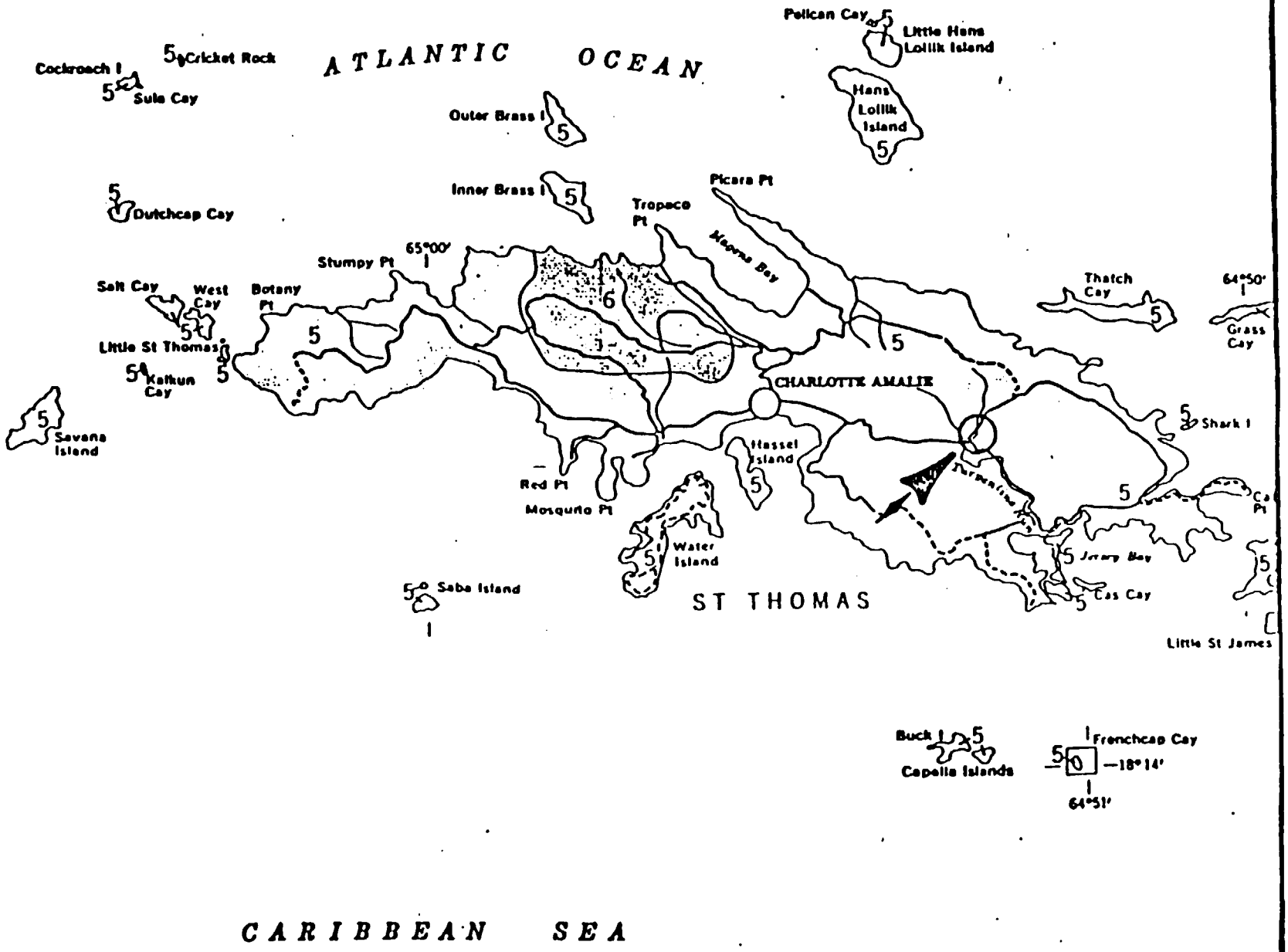

FIGURE 2.1.1

SITE LOCATION

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ENVIRONMENTAL—GEO CONSULTANTS

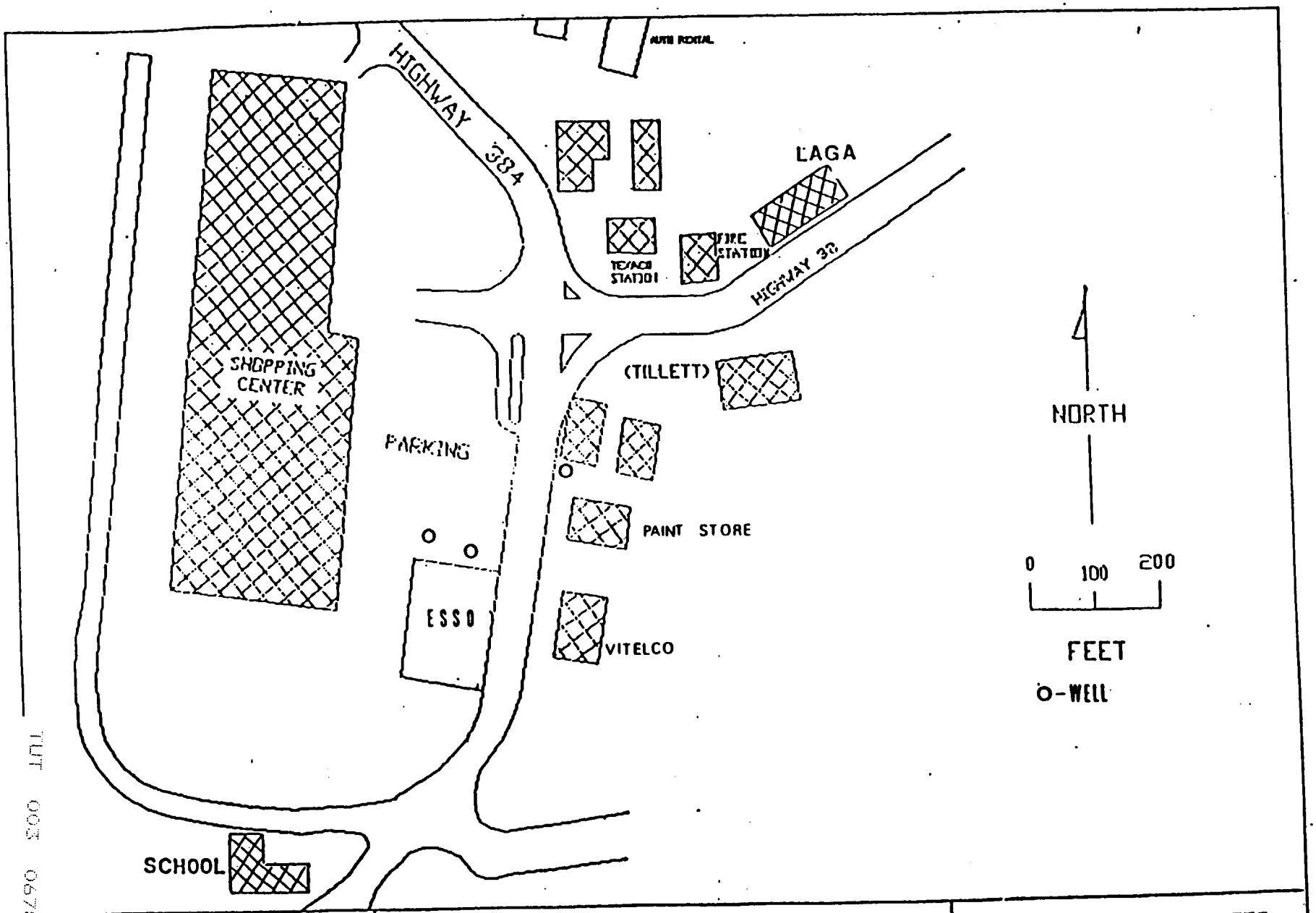


FIGURE 2.1.2

MAP OF CENTRAL TUTU AREA

BELGODERE & ASSOCIATES

ENVIRONMENTAL-GEO CONSULTANTS

and clays with a permeability of 0.20 to 0.63 in./hr. Soil strata thickness around the site location varies from exposed bed rock on side of hills to over 20 ft. in alluvial deposits.

Based on topographic and structural information obtained from "Geology of St. Thomas and St. John, U.S. Virgin Islands" by Thomas W. Donnelly (NSF, G-114407), the bedrock in the upper turpentine run basin is the Louisenhoj formation. Extensive deformation and fracturing has occurred due to later tectonic activities. Local groundwater flow in these rocks is controlled by fractures underlying the site area. The regional direction of groundwater flow is generally to the south.

Based on discussions with local water well driller (Poly Caribe), depth of groundwater at the Four Winds Shopping Center well (located 25 ft. north of the Service Station) and the Tillett Water Well (located 250 ft. to the northeast), is reported to be between 15 and 20 ft. during the rainy seasons when the water table is high and pumping of commercial and residential water wells is low. The local water table has been previously observed to drop below 90 ft. as a result of high water extraction during extended drought periods (see table 2.2.1). Water supply wells in the vicinity are generally drilled to depths between 100 to 200 ft. below land surface.

Table 2.2.I

Well 21 (20-64.53-15-58)

Owner.--?. Tillet.
Location.--Lat 18° 20' 29", long 64° 53' 16".
Description.--Drilled water-table production well, diam 6-in, cased 0-15.
Depth.--100 ft.
Aquifer.--Volcanic rocks of Cretaceous age.
Measuring point.--Top of 6-in casing, 1.5 ft above lsd.

Land elevation.--200 ft above msl.
Highest water level.--38.40 ft below lsd, Jan. 2, 1964.
Lowest water level.--94.18 ft below lsd, July 5, 1968.
Records available.--Chemical analyses: 1963-68.
Water levels: 1964-68.
Remarks.--Measurement discontinued, April 1969.

CHEMICAL ANALYSIS

Milligrams per liter

Date of collection	Discharge (gpm)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved solids calculated	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Footnote
Oct. 8, 1963	--	39	0.00	--	30	52	266	680	0	32	185	1.1	16	--	*888	289	0	1,535	7.9	28	--
May 13, 1964	--	39	.00	--	62	48	246	698	0	38	178	1.0	26	--	*1,060	352	0	1,680	7.7	28	--
May 26	--	44	.00	--	60	44	247	694	0	26	165	1.0	9	--	*967	330	0	1,650	8.0	--	--
June 25	--	43	.00	--	58	46	244	690	0	26	180	1.0	10	--	*965	334	0	1,650	7.9	28	--
Aug. 25	--	38	.00	--	60	48	247	702	0	28	190	.7	13	--	*953	347	0	1,650	8.2	28	--
July 25, 1966	--	41	.00	0.00	62	49	250	712	0	30	192	.8	16	--	*1,070	356	0	1,730	8.0	--	--
May 19, 1967	--	38	.06	.00	56	51	269	712	0	39	205	.8	23	--	*1,050	349	0	1,750	7.7	--	--
Sept. 1	--	39	.00	.00	56	46	268	716	0	38	195	.6	11	--	*1,060	328	0	1,720	8.0	31	--
Jan. 4, 1968	--	43	.02	.00	68	64	259	822	0	27	195	1.0	23	--	*1,060	435	0	1,760	7.7	27	--
Apr. 3	--	43	.00	.00	50	39	302	1.5 720	0	48	210	.8	22	0.0	1,070	286	0	1,750	8.1	26	--
May 15	--	45	.00	.00	60	60	267	1.5 756	0	45	192	1.3	26	.3	1,070	395	0	1,780	7.9	--	--
Dec. 4	--	41	--	.00	39	52	296	2.0 696	0	40	217	.7	44	.0	1,080	312	0	1,820	8.1	--	--

*Residue on evaporation at 180° C.

Water levels, in feet below land surface

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Jan. 2, 1964	38.40	Sept. 29, 1964	47.80	June 14, 1965	a71.67	Oct. 31, 1966	51.23
Jan. 23	39.08	Oct. 13	48.49	June 21	a71.61	Nov. 29	51.10
Feb. 3	39.40	Oct. 19	49.00	June 29	a70.31	Dec. 28	a54.50
Feb. 10	39.52	Oct. 24	a51.22	July 7	a72.50	Jan. 31, 1967	55.35
Feb. 17	39.58	Nov. 2	49.39	July 21	68.60	Mar. 14	58.62
Mar. 5	40.02	Nov. 9	49.81	Aug. 5	68.69	Apr. 18	a65.82
Mar. 9	40.23	Nov. 23	49.80	Aug. 21	69.55	June 1	a66.94
Mar. 16	40.37	Nov. 30	50.40	Aug. 31	68.50	July 6	67.75
Mar. 24	40.65	Dec. 7	a53.16	Sept. 30	66.25	Aug. 1	a72.07
Mar. 30	41.00	Dec. 14	a54.40	Oct. 29	a65.48	Sept. 1	a75.87
Apr. 7	41.01	Dec. 21	52.29	Nov. 12	a58.09	Oct. 3	81.61
Apr. 13	41.10	Dec. 28	a53.29	Nov. 26	55.75	Nov. 1	a86.10
Apr. 20	41.32	Jan. 4, 1965	a56.30	Dec. 8	54.05	Dec. 5	a85.78
May 5	41.67	Jan. 11	a56.93	Dec. 14	47.28	Dec. 7	a85.67
May 11	41.96	Jan. 26	55.16	Dec. 27	42.45	Jan. 4, 1968	a85.72
May 13	42.05	Feb. 8	56.56	Jan. 3, 1966	42.27	Jan. 22	82.69
May 18	a45.60	Feb. 15	57.59	Jan. 17	40.61	Mar. 5	92.26
May 26	44.35	Feb. 23	a58.63	Jan. 27	40.42	Apr. 3	89.65
June 1	44.16	Mar. 2	60.81	Feb. 14	40.28	May 3	88.17
June 8	46.99	Mar. 8	61.85	Mar. 15	41.10	June 3	92.75
June 15	44.98	Mar. 15	66.10	Mar. 30	a42.28	July 5	94.18
June 22	47.02	Mar. 23	70.08	Apr. 12	42.51	Aug. 1	83.35
June 29	46.55	Mar. 30	a75.17	Apr. 26	42.79	Oct. 1	68.07
July 6	45.37	Apr. 6	75.61	May 10	43.14	Nov. 5	a75.10
July 13	45.28	Apr. 19	74.32	May 26	44.09	Dec. 4	66.13
July 20	45.52	Apr. 26	a81.62	June 8	45.40	Jan. 3, 1969	57.49
Aug. 10	46.40	May 3	75.59	June 27	46.50	Feb. 5	61.96
Aug. 24	46.94	May 15	71.68	July 11	49.83	Mar. 24	a58.94
Aug. 31	46.93	May 18	69.28	July 25	48.79	Apr. 23	57.55
Sept. 9	47.71	May 24	69.00	Aug. 5	49.75		
Sept. 14	48.19	June 2	67.31	Aug. 30	a52.34	a - pumping.	
Sept. 23	47.99	June 7	67.06	Sept. 27	50.93		

3.0 METHOD OF INVESTIGATION

A preliminary field and literature investigation was performed by BAI personnel during the months of September through December 1987 to allow for optimization of resources during soil vapor extraction and testing operations. The results of the preliminary site investigation were reported in section 3.4 of the Esso Tutu Service Station Soil Vapor Investigation Plan, dated January 11, 1988 (See Appendix I).

3.1 SOIL VAPOR SCREENING SURVEY

The soil vapor screening survey was conducted in and around the ETSS facility between April 5 and April 23, 1988. The screening survey consisted of obtaining soil vapor samples at different locations and depths, and performing on-site analyses of the samples using two HNU-301 gas chromatographs (GC) owned and operated by BAI.

Soil vapor sampling and field analyses were performed as outlined in the Esso Tutu Service Station Soil Vapor Investigation Plan and the Esso Tutu Service Station QA/QC Plan dated January 11, 1988 (second revision), with modifications based on field conditions and requests by DPNR/EPA/CDM.

The soil vapor sampling stations consisted of 11 points located inside the service station property and 33 points located outside the facility. Samples at each station were taken from depths between 2-4 ft. and 6-8 ft. where local conditions allowed. A sampling location map is presented in figure 3.1.1.

Soil vapor samples were collected by driving a 5/8 inch diameter hollow stainless steel probe to the appropriate depth by hand with a slide hammer. Once the desired depth was achieved, 5 to 10 liters of soil vapor from around the shield point were extracted with the use of a 1,700 cc/min battery operated vacuum pump (with built-in rotameter). The pump was attached to the probe with a tygon hose containing a septum sampling port and a vacuum gauge. Gas tight syringes were inserted through the septum port to collect two to four 2.5 milliliter to 25 microliter vapor samples for immediate on-site analysis.

Samples were analyzed for aromatic hydrocarbons (BTEX), which typically comprise the major constituents of commercial gasoline. Chlorinated hydrocarbons TCE, PCE, and DCE, although not typically found in gasoline were also analyzed.

As previously mentioned, two GC's were used for the field analyses. GC No. 1 was equipped with a photo ionization detector (PID) and a flame ionization detector (FID) and a 10% TCEP, Chromosorb PAW 8' x 1/8" ss pack column. GC No. 2 was equipped with a FID and a 3% SE 30 Chromosorb WAW 6' x 1/8" ss pack column. Both GC's were equipped with Spectra Physics model SP4290 integrators for data reduction.

Initially, GC No. 1 was set to selectively identify aromatic hydrocarbons and GC No. 2 to selectively identify chlorinated hydrocarbons. Due to constant voltage fluctuations ranging from 92 to 125 volts, and daily power outages during the first days of the investigation, the PID/FID GC and both integrators failed to perform as designed. The PID was affected by decreased sensitivity, and the integrators used to calculate peak areas were malfunctioning which required later manual data reduction.

The voltage irregularity was minimized by installing a Topaz model 02906-02P3 power conditioning unit. However, even with this unit, the voltage fluctuations damaged GC No. 1, and all the samples were subsequently analyzed using GC No. 2 only.

In an effort to eliminate voltage variations and power outages, an on-site generator (Onan 3.5 kw) was employed which produced a constant 145 volts until breakdown occurred after 5 days of use.

Analyses of the soil vapor samples collected at the selected drift point location for this study showed that the range of concentrations were several orders of magnitude. Due to the range of results, and unavailability of the low end BTEX standards, it was agreed by all representatives that sufficient information for the survey was obtained when the aromatic hydrocarbon vapor concentrations were below 1 ppm for each BTEX component. The sampling boundaries were thus finalized when sample results were below 1 ppm. This replaced the previous agreement that the soil vapor survey limits were reached when the concentrations were below three times background.

4.0 RESULTS OF SOIL GAS SURVEY

4.1 AROMATIC HYDROCARBONS

Table 4.1.1 presents the highest BTEX analyses results of the sequential samples obtained from each soil vapor sample point. Sequential samples were taken during the survey instead of duplicate split samples originally proposed in the Work Plan. Copies of all chromatograms and daily calibration curves are presented in a separate supplement entitled: "Photocopies of Original Gas Chromatograms and Calibration Curves".

At the drift point selected for the ETSS soil vapor investigation, repeated samples were taken by inserting separate probes within an area of less than 150 square feet to determine whether soil vapor values varied significantly over time and short distance. A total of 7 drift point values for BTEX and chlorinated hydrocarbons were obtained during 7 of the 14 sampling days. (See tables 4.1.2A and 4.1.2B for results and figure 3.1.1 for location). Drift point benzene values ranged between <1 ppm and 160 ppm. (The highest value recorded was from a sample obtained from a depth of 6 ft.) The range of values obtained in the drift point area may be in part controlled by the inability to obtain samples from the same depth along with the time and spacial differences that could naturally occur. Depth achieved for any sampling point was controlled by local lithology.

Values reported in tables 4.1.1 and 5.0.1 are the calculated values without subtracting background and/or drift point values.

The soil vapor screening survey identified three areas of measurable BTEX vapor concentrations:

- Area 1 - Service station property and area south of property.

  Benzene vapor concentrations ranged from ND to 1,675 ppm.

- Area 2 - West and southwest of service station.

  Benzene vapor concentrations ranged from ND to 128 ppm.

- Area 3 - North and east of the service station.

  Benzene vapor concentrations ranged from ND to 2.5 ppm.

Figure 4.1.3 presents a distribution map of benzene, toluene and xylenes soil vapor results found during this study. Due to unavailability of a gaseous standard for E-benzene, no values for this component are reported in this study.

Contour maps of soil vapor concentrations for total BTEX, benzene, toluene and xylenes are presented in figures 4.1.4, 4.1.5, 4.1.6 and 4.1.7 respectively. The contour maps have been derived from values obtained from the soil gas survey and do not constitute concentrations of hydrocarbons in the soil or groundwater of the area in question.

TABLE 4.I.I.

HIGHEST CONCENTRATIONS OF AROMATIC HYDROCARBON VAPORS FOUND IN SOILS GAS SAMPLES, ESSO TUTU AREA (PPM)

LOCATION	DATE	DEPTH	BENZENE	TOLUENE	XYLENE
I-1	APRIL/20	3'10"	ND	0.722	ND
I-2	APRIL/06	2'6"	ND	ND	ND
I-3	APRIL/06	1'6"	ND	ND	ND
I-4	APRIL/22	3'0"	24.68	ND	3.295
I-5	APRIL/20	3'0"	0.223	3.277	0.011
I-7	APRIL/07	2'4"	40.55	ND	17.81
I-8	APRIL/07	4'0"	1137.593	ND	29.1
I-8	APRIL/07	8'0"	1268.772	ND	445.1
I-9	APRIL/11	4'8"	977.536	296.955	54.559
I-10	APRIL/11	2'3"	128.630	44.196	10.876
I-12	APRIL/07	3'6"	2.353	ND	349.1
I-13	APRIL/07	4'0"	ND	ND	ND
I-14	APRIL/11	3'6"	70.6	11.32	ND
I-15	APRIL/15	3'6"	ND	0.249	0.098
I-16	APRIL/23	2'3"	0.102	0.391	ND
I-17	APRIL/22	4'0"	1675.18	80.45	83.92
I-18	APRIL/12	2'10"	ND	0.011	ND
I-19	APRIL/11	7'5"	ND	ND	ND
I-20	APRIL/16	2'4"	0.116	0.522	3.922
I-21	APRIL/12	4'6"	0.004	ND	ND
I-22	APRIL/12	3'0"	135.8	10.56	ND

I-23	APRIL/12	4'0"	6.11	ND	ND
I-24	APRIL/14	2'8"	0.042	0.418	1.37
I-25	APRIL/20	3'0"	ND	0.173	0.003
I-28	APRIL/13	4'6"	0.057	0.015	0.465
I-29	APRIL/13	4'8"	ME	ME	ME
II-1	APRIL/16	1'11"	0.763	0.012	0.021
II-2	APRIL/16	2'2"	2.598	0.174	0.199
II-3	APRIL/16	2'3"	ND	0.144	0.418
II-4	APRIL/18	4'0"	ND	0.135	0.132
II-5	APRIL/19	1'8"	0.009	1.86	0.001
II-6	APRIL/19	2'4"	0.052	2.75	3.924
II-7	APRIL/19	3'9"	0.024	1.64	ND
II-8	APRIL/19	5'6"	ND	0.745	0.003
II-9	APRIL/19	3'0"	0.030	0.688	ND
II-10	APRIL/20	2'0"	0.235	5.847	0.012
II-11	APRIL/21	2'4"	ND	15.03	1.30
II-12	APRIL/21	2'9"	ND	0.018	0.067
II-13	APRIL/21	3'0"	0.286	3.987	0.005
II-14	APRIL/21	3'0"	0.081	1.79	0.066
II-15	APRIL/21	3'0"	0.013	0.014	0.056
II-16	APRIL/22	3'0"	0.050	0.833	0.481
II-17	APRIL/22	2'6"	0.109	0.131	0.033
II-18	APRIL/22	2'2"	ND	1.21	ND
II-19	APRIL/23	2'9"	0.016	1.184	0.925

ME-Masking Effect

ND-Not Detected

Table 4.1.2 A

VALUES SHOWING

HIGHEST CONCENTRATION OF AROMATIC HYDROCARBON VAPORS,

ESSO TUTU AREA (PPM)

LOCATION	DATE	DEPTH	BENZENE	TOLUENE	M-P-XYLENE	O-XYLENE
D.P.1	4/6/88	8'0"	ND	ND	ND	ND
D.P.2	4/7/88	6'0"	160.679	ND	ND	ND
D.P.3	4/8/88	3'6"	ND	ND	ND	ND
D.P.4	4/11/88	6'8"	ND	ND	ND	ND
D.P.5	4/12/88	6'0"	ME	ND	ND	ND
D.P.6	4/13/88	7'0"	ND	0.660	ND	5.880
D.P.7	4/14/88	6'3.5"	ND	0.964	0.984	0.330

ME MASKING EFFECT

ND NOT DETECTED

Table 4.1.2 B

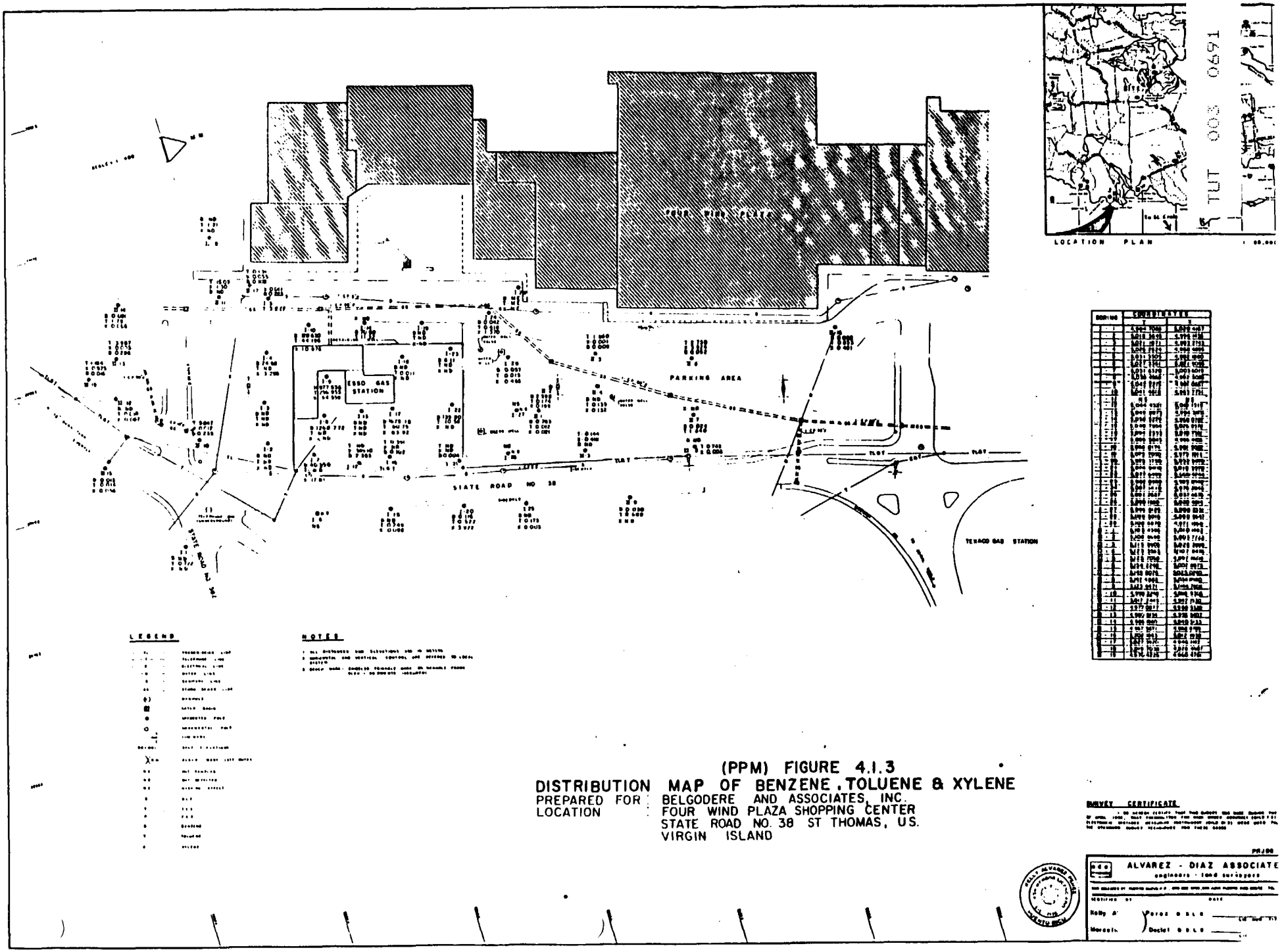
VALUES SHOWING

HIGHEST CONCENTRATION OF CHLORINATED HYDROCARBON VAPORS,

ESSO TUTU AREA (PPM)

LOCATION	DATE	DEPTH	DCE	TCE	PCE
D.P.1	4/6/88	8'0"	ND	ND	ND
D.P.2	4/7/88	6'0"	ND	ND	ND
D.P.3	4/8/88	3'6"	ND	ND	ND
D.P.4	4/11/88	6'8"	ND	ND	ND
D.P.5	4/12/88	6'0"	ND	ND	3.064
D.P.6	4/13/88	7'0"	ND	ND	ND
D.P.7	4/14/88	6'3.5"	22.16	0.104	0.196

ND NOT DETECTED



(PPM) FIGURE 4.1.3

DISTRIBUTION MAP OF BENZENE, TOLUENE & XYLENE

PREPARED FOR : BELGODERE AND ASSOCIATES, INC.

LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO. 38 ST THOMAS, U.S.
VIRGIN ISLAND

4.2 **AREA 1** - ETSS facility and area south of the property.

The survey results show hydrocarbon vapor concentrations ranges from ND to 1,675 ppm of benzene. The highest concentrations were found in the south and central portion of the service station. Due to the variable depth to bedrock at the site, sampling at two different depths at the same location was not always possible.

The service station contains fill material surrounded by retaining walls. The retaining walls comprise the facility boundaries. Land surface elevation measurements (see figure 4.2.1) indicate an average height differential of approximately 5 ft. between the service station underground storage tanks area and the south portion of the shopping center parking lot adjacent to the facility. Two sample stations I-2 and I-3 immediately south of the facility tank field showed nondetectable levels of aromatic hydrocarbon vapors. However, at sample station I-4 located south of the western section of the ETSS property, the benzene vapor concentration was 24 ppm. Sample stations further south show significantly reduced levels of benzene vapor concentrations (see figure 4.1.3 for values).

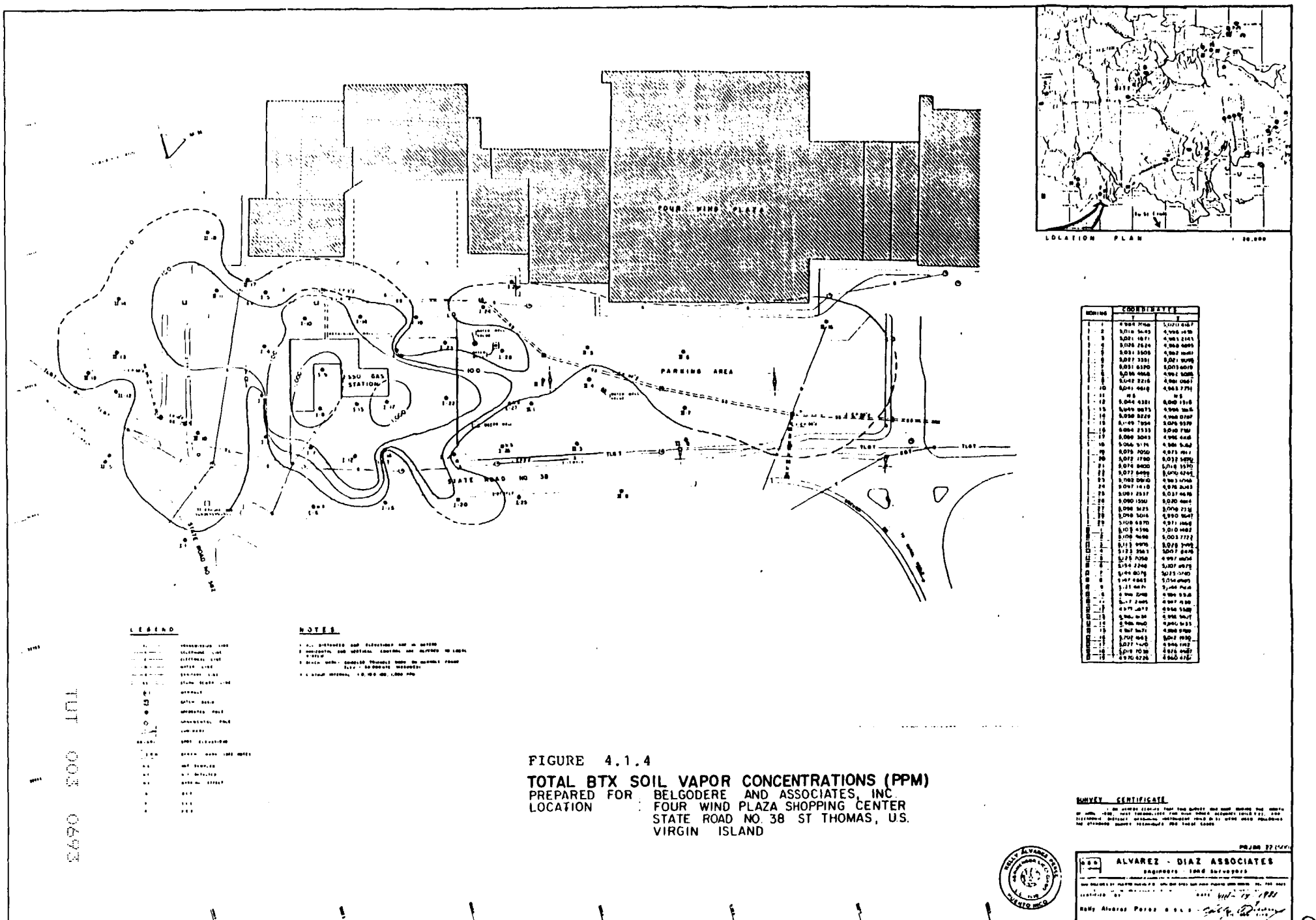


FIGURE 4.1.4

TOTAL BTX SOIL VAPOR CONCENTRATIONS (PPM)

PREPARED FOR : BELGODERE AND ASSOCIATES, INC.
LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO. 38 ST THOMAS, U.S. VIRGIN ISLAND

ALVAREZ - DIAZ ASSOCIATES
engineers land surveyors

TLOT 0693 0690

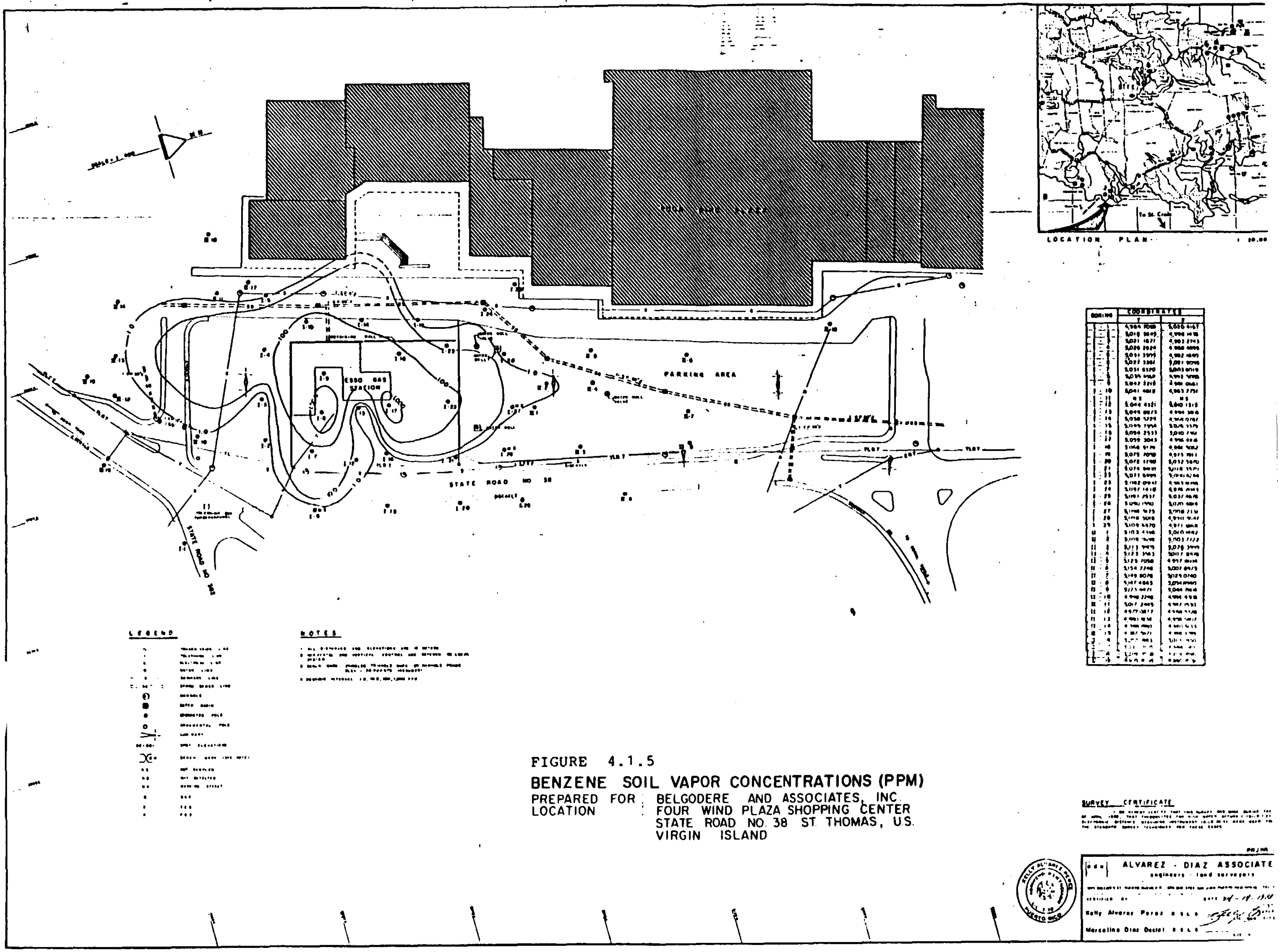


FIGURE 4.1.5
BENZENE SOIL VAPOR CONCENTRATIONS (PPM)
PREPARED FOR : BELGODERE AND ASSOCIATES, INC.
LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO. 38 ST. THOMAS, U.S.
VIRGIN ISLAND

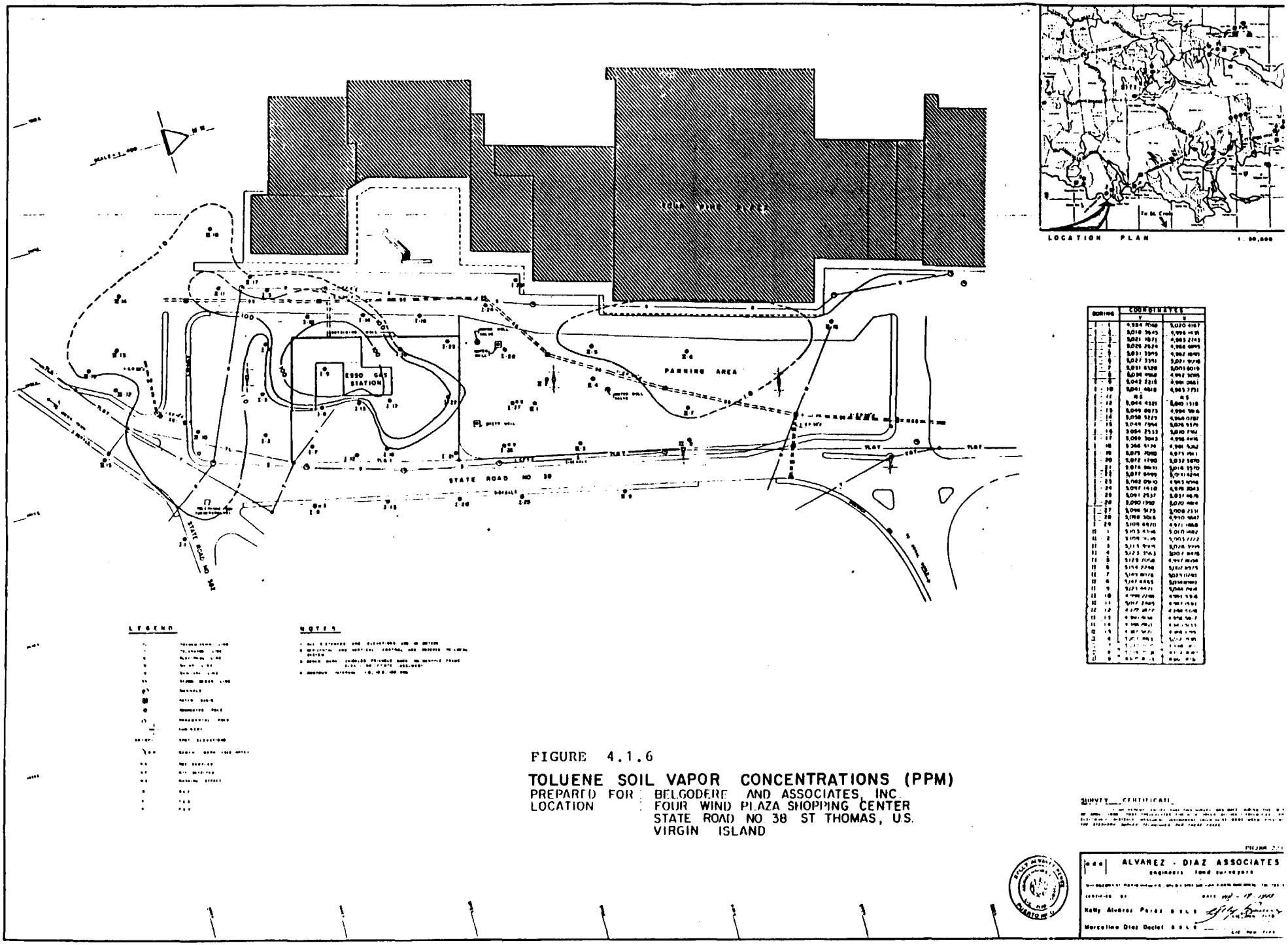


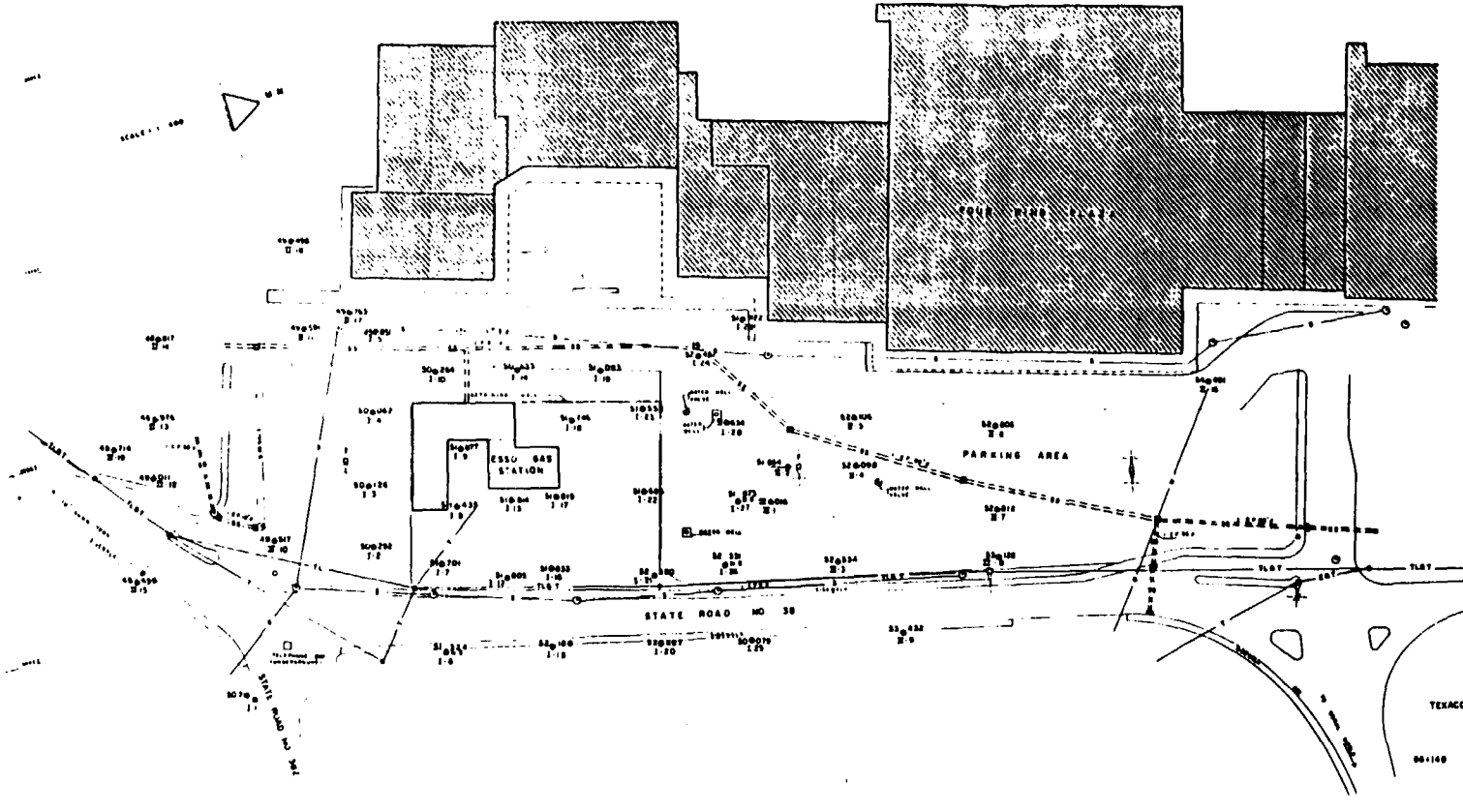
FIGURE 4.1.6

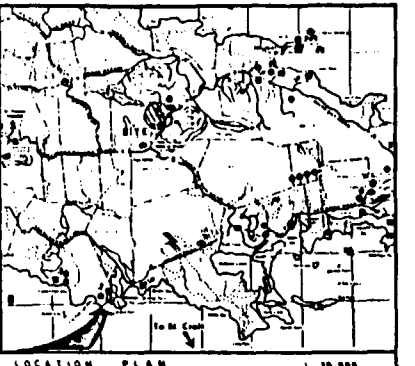
TOLUENE SOIL VAPOR CONCENTRATIONS (PPM)

PREPARED FOR : BELGODERE AND ASSOCIATES, INC.
LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO 38 ST THOMAS, U.S.
VIRGIN ISLAND

ALVAREZ - DIAZ ASSOCIATES
engineers land surveyors

TUT 003 0695





BORING	COORDINATES	
	X	Y

LEGEND

NOTES

ELEVATION MEASUREMENT MAP - FIGURE 4.2.1
PREPARED FOR : BELGODERE AND ASSOCIATES, INC.
LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO. 38 ST THOMAS, U.S.
VIRGIN ISLAND

SURVEY CERTIFICATE

ALVAREZ - DIAZ ASSOCIATES
engineers - land surveyors

Kelly Alvarez Perez
Marcelino Diaz Daniel

TUT 003 0996

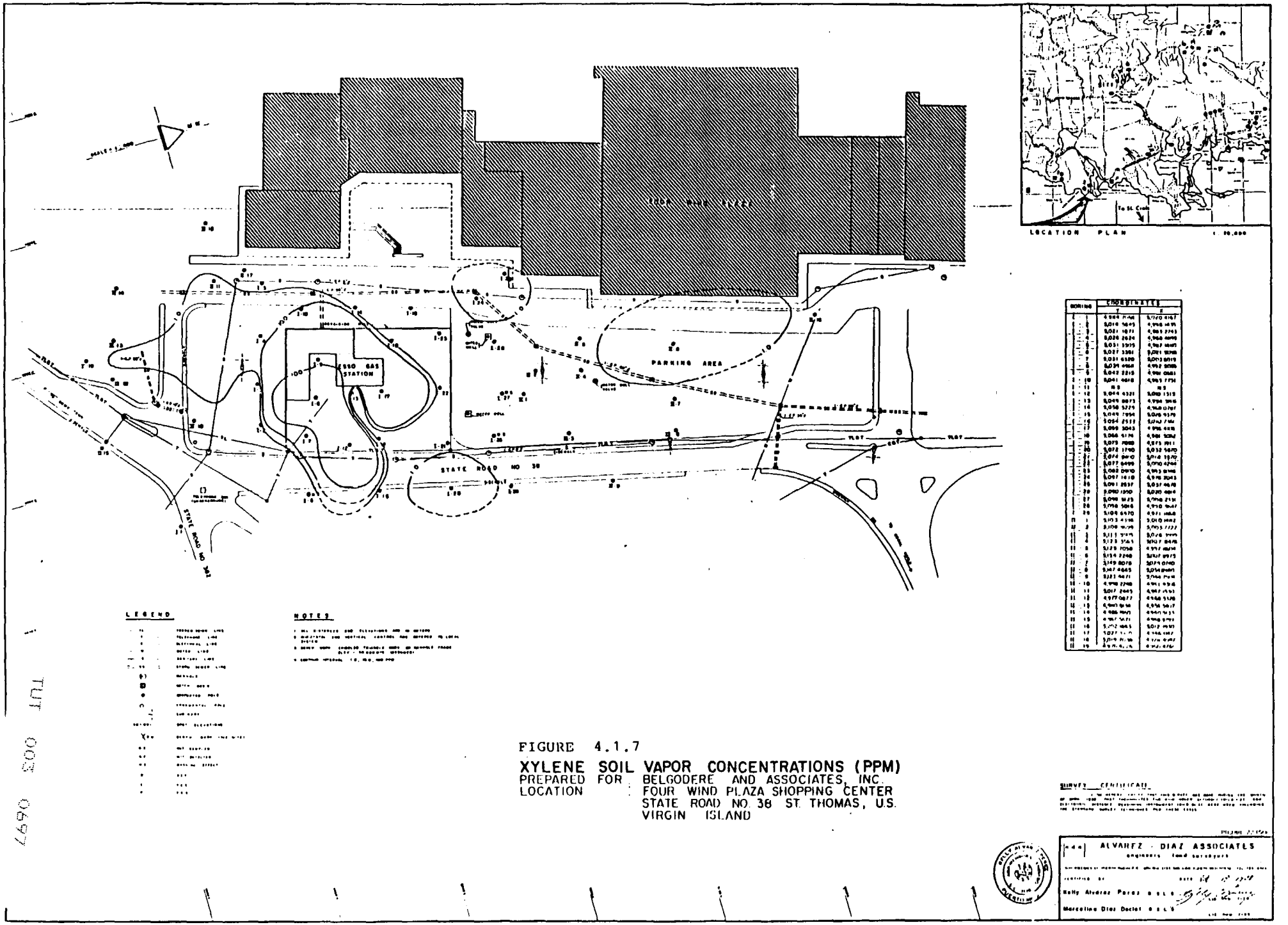


FIGURE 4.1.7

XYLENE SOIL VAPOR CONCENTRATIONS (PPM)
PREPARED FOR : BELGODERE AND ASSOCIATES, INC.
LOCATION : FOUR WIND PLAZA SHOPPING CENTER
STATE ROAD NO. 38 ST. THOMAS, U.S. VIRGIN ISLAND

SURVEY CERTIFICATE

ALVAREZ - DIAZ ASSOCIATES
engineers land surveyors

Kelly Alvarez Perez

Marcelino Diaz Doclet

TUT 003 0697

4.3 **AREA** 2 - Area west and southwest of ETSS facility.

Concentrations of benzene hydrocarbon vapors found in the area west and southwest of the ETSS facility range from ND to 128 ppm. (see figure 4.1.3).

The highest benzene concentration in this area, 128 ppm, was found at station I-10. This station is near a pipeline which once connected the ETSS facility oil/water separator to the Four Winds parking lot storm water drainage. This pipeline was in service for a relative short time before it was disconnected and capped.

4.4 **AREA** 3 - North and east of ETSS facility.

A third area of measurable aromatic hydrocarbon vapor concentrations ND to 2.5 ppm of benzene, was found to extend to the survey boundaries, 400 ft. to the north and 83 ft. to the east of the ETSS facility.

It is not possible to ascertain the sources of hydrocarbon vapors found in the area from this soil vapor survey. A more direct method such as borings, monitoring well installations, and sampling and analyses will have to be employed to refine the data base.

5.0 CHLORINATED HYDROCARBON

Table 5.0.1 presents the results of chlorinated hydrocarbon (TCE, PCE & DCE) analyses for each soil vapor sample collected during the survey. Copies of all chromatograms and daily calibration curves are presented in the separate supplement entitled: "Photocopies of Original Gas Chromatograms and Calibration Curves".

Chlorinated hydrocarbons, although not typically found in motor fuel, were analyzed in the soil vapor samples at the request of DPNR-EPA. This request was made because chlorinated hydrocarbons were found in water supply wells in the Tutu area.

The survey results show that the highest chlorinated hydrocarbon (DCE, PCE & TCE) concentrations ranging from ND to 189 ppm were obtained in area 2. Total chlorinated hydrocarbon vapor samples from stations I-4 and II-11 in Area 2 yield values of 78 and 189 ppm, respectively (see figure 5.0.2). In Area 1, seven samples were analyzed for chlorinated hydrocarbon vapors. The values range from ND to a high of 16 ppm of total chlorinated hydrocarbon vapors at Station I-23 located on the northwest corner of the ETSS facility. At Station I-17 chlorinated hydrocarbon vapors were detected but due to the high concentrations of aromatic vapors, quantification of chlorinated vapors was not possible. In Area 3, the highest concentration of total chlorinated hydrocarbon vapors, 13 ppm, was found at Station II-8 located on the edge of the survey northwest boundary. Concentrations of chlorinated hydrocarbon vapors in

Area 3 decrease toward the southern portion of this area. This is evident by values obtained from samples at Stations II-4, I-28 and II-8. Based on the limited scope of this screening survey, and the geological condition found in the area, it is impossible to ascertain the source(s) of chlorinated hydrocarbon compounds.

TABLE 5.0.I

HIGHEST CONCENTRATIONS OF CHLORINATED HYDROCARBON VAPORS FOUND IN SOIL GAS SAMPLES, ESSO TUTU AREA (PPM)

LOCATION	DATE	DCE	TCE	PCE	TOTAL
I-1	APRIL/20	ND	0.179	ND	0.179
I-4	APRIL/22	186.87	ND	2.598	189.468
I-5	APRIL/20	0.2538	0.3417	1.552	2.148
I-9	APRIL/11	ND	ND	ND	ND
I-10	APRIL/11	ND	ND	13.70	13.70
I-14	APRIL/11	3.098	ND	5.83	8.928
I-16	APRIL/23	0.569	ND	ND	0.569
I-17	APRIL/22	ME	ME	ME	ME
I-18	APRIL/12	ND	ND	0.370	0.370
I-19	APRIL/11	0.014	ND	2.08	2.094
I-20	APRIL/16	ND	ND	ND	ND
I-21	APRIL/12	ND	ND	2.98	2.98
I-22	APRIL/12	ND	ND	ND	ND
I-23	APRIL/12	ND	6.196	15.596	21.792
I-24	APRIL/14	0.043	0.022	0.045	0.110
I-25	APRIL/28	0.007	0.152	0.295	0.454
I-28	APRIL/13	0.908	0.548	3.346	4.802
I-29	APRIL/13	ND	ND	0.274	0.274

LOCATION	DATE	DCE	TCE	PCE	TOTAL
II-1	APRIL/16	0.180	ND	0.102	0.282
II-2	APRIL/16	0.376	ND	0.358	0.734
II-3	APRIL/16	0.165	0.470	1.366	2.001
II-4	APRIL/18	1.465	1.128	5.243	7.836
II-5	APRIL/19	ND	0.008	0.058	0.066
II-6	APRIL/19	0.028	0.087	ND	0.115
II-7	APRIL/19	0.065	0.814	ND	0.879
II-8	APRIL/19	0.870	1.350	11.471	13.691
II-9	APRIL/19	0.022	0.084	2.02	2.126
II-10	APRIL/28	1.077	0.964	ND	2.041
II-11	APRIL/21	ND	73.47	5.24	78.71
II-12	APRIL/21	0.043	ND	ND	0.043
II-13	APRIL/21	ND	ND	ND	ND
II-14	APRIL/21	0.361	ND	1.866	2.227
II-15	APRIL/21	0.332	ND	1.866	2.198
II-16	APRIL/22	0.044	0.135	0.649	0.828
II-17	APRIL/22	ND	0.043	0.030	0.073
II-18	APRIL/22	ND	10.88	5.80	16.68
II-19	APRIL/23	ND	ND	ND	ND

ND-NOT DETECTED

ME-MASKING EFFECT

6.0 Recommendations

The results of the soil vapor survey have indicated that detectable levels of both aromatic and chlorinated hydrocarbon vapors are present in the subsurface. However, it was not possible to ascertain the sources of these vapors, nor the actual concentrations that may be present as dissolved constituents in the local groundwater. To refine the existing data base, a more direct methodology of sampling and analyses must be employed. The following recommendations are submitted for your consideration to achieve the desired results.

A subsurface investigation is recommended to be undertaken consisting of drilling, well installation, and soil and water sample collection and analyses. The actual boring locations will be based on field conditions and site accessibility. Borings should be completed as monitoring wells to collect water level elevation data, and water samples for chemical analyses.

During the drilling, the soil cuttings should be scanned with a portable photo-ionization detection (PID) meter to determine the concentration of volatile organic vapors. The PID readings may provide some indications of preferred zones of hydrocarbon movement.

At the completion of the well installation program, the top of the casings should be surveyed to a common datum. Additionally, the elevations of the nearby existing water supply

wells should be surveyed. Water level elevations will be measured and the general direction of horizontal groundwater flow can be established.

The proposed new wells, and the nearby existing water supply wells should be sampled, and the water analyzed for selected dissolved constituents. To aid in the interpretation of the data, and assess the suitability of samples collected from the water supply wells with the use of the existing pumping equipment, as much information as possible should be collected and reviewed. Data such as: construction details, lithologic logs, pump setting, pumping rates, water-level measurements, and water-sample analyses should be collected and reviewed.

APPENDIX I

Second Revision
Jan. 11, 1988

ESSO TUTU SERVICE STATION
SOIL VAPOR INVESTIGATION PLAN

Prepared for:

Department of Planning & Natural Resources, USVI.
Environmental Protection Agency - Region II, N.Y.
December 28, 1987

Submitted by
Esso Standard Oil S.A. Ltd.

Carlos M. Belgodere, Belgodere & Associates Inc.
Project Coordinator.

Ana Gloria Ramos, P.E., ESSO Standard Oil SA LTD.
Project Manager

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1.0 Description of Work

1.1 Background

A number of water wells have been shut down by the Department of Planning and Natural Resources of the USVI (DPNR) and the Environmental Protection Agency Region II, New York (EPA) as a result of reported ground water contamination in the Tutu area of St. Thomas, USVI. DPNR/EPA believe that among the possible sources of hydrocarbon contamination found in the ground water may be one or more of the various gasoline service stations which operate or had operated in the Tutu area. Esso Standard Oil S. A. Ltd. (ESSO) is the owner of the gasoline service station located in the Four Winds Shopping Center at the Tutu Area of St. Thomas. In consideration thereof, DPNR has ordered ESSO to submit an investigation plan to assess the potential seepage of product into the underlying soil of the above referred Service Station.

ESSO has requested Belgodere & Associates Inc. (BAI) to perform the above mentioned investigation ordered by DPNR. Pursuant to DPNR Administrative Order of September 17, 1987, the plan contained herein has been developed to effectively characterize the contaminants, if any, at the soils beneath the Service Station.

The study will encompass an assessment of the possibility of motor fuel releases from underground storage tanks/pipelines and potential migration pathways at the Esso Service Station by performing a soil vapor survey. If as a result of the soil vapor investigation it is determined that the Esso Service Station is not the source nor has contributed to the contamination of local

aquifer, adequate releases will be sought by Esso Standard Oil S.A. Ltd.

ESSO, and BAI Representatives have met with EPA Project Manager, Ms. Caroline Kwan, DPNR Representative, Ms. Francine Lang, and the Project Officer at Camp, Dresser & Mckee Federal Programs Corporation (CDM-FPC) Mr. Scott B. Graber. DPNR, EPA, and CDM-FPC have discussed the principles for the technical approach and work schedule presented in this Work Plan. It is our understanding that all parties are in agreement with the concepts and schedule presented herein.

1.2 Hydrogeologic Setting

The Esso Service Station is located in St. Thomas U.S.V.I., on the West Side of Rd #38 in the Tutu area, at the Four Winds Shopping Center Parking Lot.

According to information obtained from "Soil Survey Virgin Islands of the US, 1970 Soil Conservation Service Report", issued in August 1970, the area is described as a network of terraces and alluvial fans sloping gently to moderately toward the south. Soil deposits consist of stratified sands, gravels and clays with a permeability of 0.20 to 0.63 in./hr. Soil strata thickness around site location varies from bare rock on slope side of hills to over 20 ft. on alluvial deposits.

Based on topographic and structural information obtained from "Geology of St. Thomas and St. John, U.S. Virgin Islands" by Thomas W. Donnelly (NSF, G-114407) the local water table should generally slope to the south. Direction of local ground water flow is controlled by volcanic bedrock fractures underlying the site area soils.

Based on discussion with local water well drillers (Poly Caribe) depth, of ground water at the Four Winds Shopping Center well, located 25 ft. north of the Service Station and the Tillett Water Well, located 250 ft. north east, is reported to be between 15 and 20 ft. during the rainy seasons where water table is high and pumping of commercial and residential water wells is low. The local aquifer water table has been previously observed beyond 80 ft. as a result of high water extraction during extended drought periods.

1.3 Purpose and Methodology of Soil Vapor Survey.

The purpose of the proposed soil vapor survey is to determine whether there has been a leak or a spill from the Service Station underground storage tanks and/or pipelines that may have contributed to the local aquifer contamination and, if leaks and/or spills from the Service Station are identified, to determine their areal extent.

In theory, when an underground motor fuel tank or pipeline experience mechanical integrity failure and release occurs, hydrocarbons are expected to move downward in the direction of the water table and then carried in the upper part of the shallowest aquifer in the direction of ground water flow, therefore, contaminating soils along its pathway due to capillary action of soil matrix (figure 1.3.1). Soils containing motor fuel components will yield when analyzed high values of total hydrocarbons, benzene, toluene, ethyl-benzene and xylene when soil vapor is extracted from soils stratas underneath and around

suspected point sources. Relatively high hydrocarbon concentration in soil vapor from the zone above the hydrocarbon plume will often allow for efficient mapping of plume origin and extend by systematically obtaining soil vapor samples and analyzing them for hydrocarbons content.

The proposed soil vapor extraction and analysis to be performed in the Esso Service Station area will:

- o Detect the presence, if any, of total hydrocarbons Benzene, Toluene, Ethyl-Benzene, Xylene, Trichloroethylene, Tetrachloroethylene, and Dichloroethylene contamination in soils.
- o If contamination in soils is present, it will identify and define its nature and extent.

Soil vapor contaminant investigation refers to a method revived by Thomas M. Spittler (EPA Region I Laboratory) from the Oil and Gas Exploration Industry for investigating underground contamination by means of detecting organic vapors. The method involves pumping a small amount of soil vapor out of the ground through a hollow probe driven to a desired depth and analyzing the vapor for the presence of volatile contaminants. The soil vapor analysis is performed in the field so that samples do not have to be packed or shipped also, analytical results are available immediately and can be used to help direct the investigation. The investigation is usually carried out by analyzing soil vapors in 50'-100' center trancets across the suspected contaminated area until boundaries are well defined. The Soil Vapor Investigation Plan has been prepared in consonance with "Spittler

Method". Please refer to section 2.3 of the QA/QC Plan for description of the Sampling Network Design and Rationale.

2.0 Statement of Work

In order to determine the range, and spatial distribution of motor fuel that may be present in the soil at the Esso Tutu Service Station, ESSO will implement a two-phase approach which includes the following:

Phase I

The first phase will consist of soil vapor sampling and analysis on a grid encompassing the Esso Service Station property to determine the presence, if any, of motor fuel contamination in the underlying soils. An extension of Phase I sampling grid will be carried out beyond the Esso Service Station boundaries to determine, if any, the nature of the hydrocarbon plume.

Phase II

If soil contamination is found to have orginated at the Service Station, a further extension of the sampling grid will be carried out to define the areal extent of motor fuel contamination plume in soils above ground water.

The soil vapor sampling program will be terminated at the end of Phase I if it is determined that there is no evidence of motor fuel at the soils underneath the Service Station, or at the end of Phase II if it is determined that motor fuel contamination found on site inmigrated from other sources outside the Esso Service Station property.

The work which ESSO proposes to perform is described in Section 3 of this Work Plan. The results of Phase I will trigger and influence the need for the other phases of this investigation.

3.0 Technical Approach

The technical approach for this project has been developed with significant input from EPA and CDM-FPC and various site visits performed by ESSO and BAI Representatives during the September-December 1987 period. The proposed study is divided into various tasks in order to provide check points at which progress and findings will be examined, therefore, allowing flexibility for field decisions as to necessity for implementation of subsequent task phases.

The technical approach has been divided into nine tasks. Through these tasks a Work Plan has been developed to conduct a soil vapor sampling grid. Soil vapor samples will be analyzed on site for the following parameters:

- Total Hydrocarbons
- Benzene
- Toluene
- Ethyl-benzene
- Xylene
- Trichloroethylene
- Tetrachloroethylene
- Dichloroethylene

The three chlorinated hydrocarbon compounds, although not typically found on motor fuels, will be analyzed following suggestions from DPNR and EPA. Based on results from previous phases of the program, further soil vapor samples and analysis for the same parameters may be conducted as needed. A final report will be prepared describing and illustrating the results of the study.

The tasks to be performed under the Work Plan do not encompass permit requirements under federal and local environmental laws and regulations. There are no requirements under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), or any other environmental law o regulation, either federal or local, applicable to the endeavors covered under the Work Plan.

Occupational Safety and Health Standards found in 29 CFR 1910 are applicable to this project. The Health and Safety Plan submitted herewith addresses the minimum safety procedures that will be followed during the performance of all the tasks involved

in this Work Plan. The nine tasks are presented below:

Task 01 Site History (completed)

Task 02 Work Plan Development (completed)

Task 03 Management Coordination (on going)

Task 04 Preliminary Site Investigation (completed)

Task 05 Quality Assurance Project Plan Preparation (completed)

Task 06 Soil Vapor Sampling and Analysis

Task 07 Data Analysis and Interpretation

Task 08 Preparation of Illustrations and Technical Report

Task 09 Quality Assurance/Quality Control

To succesfully carry out this Work Plan within the estimated scheduled time frame, the Esso Project Manager, the BAI Project Officer, and DPNR/EPA designated Field Representatives will maintain the necessary communication to assure that efforts are coordinated and each task is completed according to the Work Plan. Any necessary field changes or corrections in strategies will be examined carefully, and will be documented and coordinated with ESSO and approved by DPNR/EPA Field Representatives..

3.1 Task 01 Site History

The Esso Service Station located at the parking lot of the Four Winds Shopping Center, Road 38 in the Tutu neighborhood of St. Thomas, U.S. Virgin Islands, initiated operations during 1970. The Service Station is equipped with two (2) underground fuel storage tanks of 6,000 gallon each. The Service Station, as

well as the necessary equipment and appurtenances for its operation, such as the underground tanks and the gasoline pumps, are owned by Esso Standard Oil S.A. Limited, a Bahama corporation organized under the laws of Bahamas.

Mr. Robert Duns, the Service Station first dealer, operated the station from 1970 through 1971, when Mr. Daniel Bayard took over its operation as Esso's new dealer and lessee. Daniel D. Bayard, Jr., the service station current dealer, assumed full management responsibility of the Esso Service Station in March 1976 when his father, the previous dealer, went into retirement.

Of the maintenance activities that have been conducted at the Service Station throughout the years, only two (2), the replacement of piping and an integrity test, may have a bearing on the project.

The 2" pipes connecting the dispensing units to the underground storage tanks were replaced from galvanized to fiberglass during 1985-1987. The replacement job was conducted by Mr. Eugenio de Arce, Esso's St. Thomas maintenance contractor.

One of the two underground storage tanks was emptied and removed from service on July 27, 1987, after the results of a Petro-Tite tank test performed by Roque Schmidt Corp. caused Esso to question the structural integrity of the tank. The tank has remained empty ever since, pursuant to an order issued by the Department of Planning and Natural Resources of the U.S. Virgin Islands dated August 21, 1987. A physical examination of the tank has been unable to be performed pending DPNR authorization.

3.2 Task 02 Work Plan Development

The proposed Work Plan has been developed from:

- Series of meetings between ESSO and BAI Representatives at the site to evaluate physical condition that may restrain the technical approach.
- Meetings and telephone conversations between ESSO, BAI, DPNR, EPA, and CDM-FPC personnel to establish the basic guidelines and objectives for the proposed study.

The deliverable for Task 01 is this Work Plan. The Work Plan may be adjusted as appropriate at the end of each phase pending on its outcome.

3.3 Task 03 Management and Coordination

The BAI Project Officer will coordinate the technical execution of work tasks described on this Work Plan. The overall Project Management will be performed by Esso Project Manager.

The following is a list of activities to be performed under this task:

- Provide assurance that team staff and resources are provided so that each task is completed on schedule,
- initiate approved changes to the Work Plan as necessary,
- ensure that Quality Control and Quality Assurance measures are monitored and implemented.
- provide assurance that field personnel will adhere to Health and Safety Plan.

3.4 Task 04 Preliminary Site Investigation

A preliminary site investigation has been performed during the months of September thru December 1987 to allow for optimization of resources during soil vapor extraction and testing operation by identifying in advance the limitation imposed by local conditions, ie. topographic, geologic, construction, structures. This work plan is partially based on site specific requirements based on the results of the preliminary site investigation, as follows:

- The area is mostly covered with concrete or asphalt and fill material above rocky soil which can limit the soil vapor probe depth of penetration between 4 to 10 ft.
- Establishment of the sampling grid is affected by numerous existing structures. Offset of grid points may be necessary to provide areal coverage. Sampling grid may be extended based on field judgment.
- Access authorization from third parties will be required to establish sampling points outside the Service Station, if necessary.

3.5 Task 05 Preparation of Quality Assurance/Quality Control Plan

The attached QA/QC Plan is a documentary record detailing the sampling methodology, QA/QC procedures, data presentation and evaluation techniques to be followed during the field data collection, analysis and report preparation phases of this Work Plan. The QA/QC is based on the requirements outlined in the interim guidelines and specifications for preparing Quality Assurance Project Plans EPA-600/4-83-004, February 1983 publication.

3.6 Soil Vapor Sampling and Analysis

The proposed soil vapor sampling and analysis program consists of a two-phase approach were the need for subsequent work will be established by the results of phase I and field judgment.

Soil vapor samples will be collected by driving a 5/8 inch diameter hollow stainless steel probe to the appropriate depth by hand or with a pneumatic driver. After desired depth is achieved, 5 to 10 liters of soil vapor from around the shield point will be extracted with the use of a 500cc/min battery operated vacuum pump attached to the probe with a vacuum gauge and a septum sampling port via a teflon hose. A gas tight syringe will be inserted through the septum port to collect a 2 UL to 10 UL vapor sample for immediate on site analysis.

During all phases of work, soil vapor samples will be analyzed using gas chromatographs owned and operated by BAI (See section 6 and 7 of AQ/QC Plan). Two gas chromatographs equipped with flame ionization detectors (FID) will be used to identify total hydrocarbons and chlorinated hydrocarbons. Analysis to be made at each sample point will consist of:

- Total hydrocarbons
- Benzene
- Toluene
- Ethyl-Benzene
- Xylene
- Trichloroethylene
- Tetrachloroethylene
- Dichloroethylene

The second proposed phases of work to be conducted at the Esso Service Station area are as follows:

Phase I

Phase I consists of soil vapor sampling on the Esso Service Station property. Sampling points will be spaced in a grid

pattern approximately 50 ft centers (figures 3.6.2 a, b). Additionally, at least to sampling points will be located about 100 feet north-northeast (hydrologically upgradient) of the Service Station site to serve as background points, where possible samples will be taken from depths of 4-5 feet and 8-10 feet at each point to determine whether there is a significant change in soil vapor values with depth.

The second phase of this investigation will be conducted if the following criterias are met during the first phase. Significant aromatic hydrocarbon concentrations are found during Phase I, as follows:

> values of hydrocarbons detected on the station property exceed those found in background locations by a factor of three or more.

If required, Phase II will extend the grid pattern toward the east north-east on a 50, 100, or 200 ft. center as considered appropriate to determine if hydrocarbon contamination generated at the site or inmigrated from other sources.

Phase II

If data developed during Phase I and or Phase II indicate that hydrocarbon contamination may have been potentially

generated from the Esso Service Station, the soil vapor sampling grid will be extended on 50 ft. centers toward the soutn south east and south south west as considered appropriate based on field judgment. The grid will be sampled and analyzed in the same manner as the grid established in Phase I, using the same depths below ground surface. This grid will be continued southward, eastward and westward based on Field Judgment.

3.7 Task 07 Data Analysis and Interpretation

Data analysis and interpretation will be performed simultaneously with the field work to allow changes in field work to properly orientate, extend or reduce the sampling grid based upon results of previously sampling and analysis. Initial data reduction and mapping of soil vapor concentration will be performed at BAI, St.Thomas office.

3.8 Task 08 Preparations and Ilustrations of Technical Report

After completion of the site investigation described under task 03 through 07, BAI will prepare a final report discussing the results of the investigation. The final report will include, as a minimum, a tabular presentation of the soil vapor analysis values encountered during the course of the investigation (ie. total hydrocarbons, benzene, toluene, ethyl-benzene, xylene, trichloroethylene and tetrachloroethylene) illustrating the spacial orientation of measured values.

Specific items to included in the report are:

- o Base map showing distribution of soil vapor sampling points;
- o contour maps of hydrocarbon values to delineate hydrocarbon plumes and possible trajectory;
- o tables listing all soil vapor hydrocarbon values encountered during the course of this investigation;
- o maps showing relationship of hydrocarbons values in soil vapors to estimate ground water flow direction on local geology:
- o GC Chromatograms;
- o conclusions and recommendations.

3.9 Task 09 Quality Assurance and Quality Control

QA Officer for this project, Eng. Omar Muniz has reviewed this work plan for QA requirements and will maintain QA oversight through the duration of this project. BAI work on this assignment will be conducted in accordance with project specific QA/QC which is being submitted with this Work Plan.

4.0 Performance Schedule and Schedule of Deliverable

A site investigation plan schedule is shown in figure 4.0.1 and the deliverable date schedule is included on figure 4.0.2.

The project schedule depends upon initiation of field work on January 26, 1988. Approval of the Work Plan and Quality Assurance, Quality Control Plan one week before that date will be necessary to assure timely completion of the project.

Figure 4.0.2

DELIVERABLE SCHEDULE

Project Deliverable	Initial Text to DPNR/EPA	Receipt of Technical Comments	Final
1. Work Plan	12/28/87	1/25/88	2/1/88
2. QA/QC	12/28/87	1/25/88	2/1/88
3. Health & Safety Plan	12/28/87	1/25/88	2/1/88
4. Final Report	4/14/88	N/A	N/A

Figure 4.0.1

SITE INVESTIGATION SCHEDULE

Work Plan Development.....Dec. 2 to Dec. 28, 1987

Review Approval.....Jan. 20 to Feb. 1, 1988

Soil Vapor/Field Investigation.....Feb. 23 to Mar. 8, 1988

Data Evaluation.....Mar. 8 to Mar. 22, 1988

Final Report.....Mar. 22 to Apr. 5, 1988

APPENDIX II

OPERATIONAL PROCEDURES AUDIT
SOIL VAPOR INVESTIGATION
ESSO - TUTU SERVICE STATION
ST. THOMAS, USVI

INTRODUCTION

The audit to the Soil Vapor Investigation conducted by Belgodere & Associates Inc. (BAI), at the ESSO - TUTU Service Station was performed by Sharetech - Omar Muñiz & Associates. The Quality Assurance (QA) Officer, Eng. Omar Muñiz, was assisted by Mr. Julio Rodriguez and Mr. Jose G. Vila. Sharetech conducted a continuous field system and operational procedures check. Mr. Jose G. Vila was present during the complete project from April 5, 1988 to April 23, 1988. Observations and recommendations were brought to the attention and discussed with BAI personnel during this period. This report is a summary of said information.

PURPOSE OF THE AUDIT

The audit was conducted to verify that the procedures described in the Work Plan and in the QA/QC Plan were being followed. The auditor was present for any consulting to the Project Officer or any member from his staff in relation to necessary modifications based on the experience in the field. The main purpose is to keep or improve the final work product.

FIELD OBSERVATIONS

Based on field judgments and/or mutually agreed decisions, some changes were necessary during the project. These were necessary due to field and specific site conditions. There were electrical voltage variations and intermittent power failures, which caused some unexpected delays. Additional field equipment was brought into the operation to solve this problem. Among these were an auxiliary power plant and electric current rectifier.

One of the two Gas Chromatographs (CG) was equipped with a PID detector. At the end of the first week of the project, due to communication problems with CDM FPC, the amount of sample to be injected into the GC was increased. Upon increasing the sample injection the detector started to malfunction and to show no or very poor resolution. The peaks of concern did not appear. The most probable causes for these conditions are that the PID detectors were affected by humidity, electrical variations, as well as the increased sample injection. After the PID detector was rendered inoperative, its use was discontinued for the rest of the project.

In order to check on the validity of the FID detector, standard samples were injected to verify the resolution. After few injections and the adjustments to the instrument conditions, all the parameters of concern were clearly recognized. The samples of the first week were qualitatively analyzed. The quantification of these samples was performed afterwards.

The sampling procedures were followed as described in the plan with minor changes. The depths from which samples were collected were changed in those situations where subsurface conditions did not allow penetration to the target depth. CDM FPC representatives suggested that the minimum depth for vapor sampling be established at two feet below surface. In addition, a minimum depth separation of two feet must be maintained between sample collection at the same station. This sampling procedure was mutually agreed. A total of sixty-two (62) samples were collected during the investigation.

At the beginning of field activities and at the request of EPA and CDM FPC, the original sampling pump was replaced with a pump having an indicating flow device and a higher capacity. The new pump was calibrated before its use and checked again at the end of the project. Pump calibration did not vary more than one percent.

Internal quality control checks such as field blanks, syringe blanks and equipment blanks were conducted during the project. Three point calibration samples were processed and plotted at a latter date. Although the work plan originally considered the taking of duplicate samples at each sampling point, two independent samples were taken in sequence. The method of taking the samples did not allow for replicate samples because of the dynamic conditions of the source where samples were taken.

DEVIATIONS FROM WRITTEN PLAN

	DEVIATION	QA/QC SECTION	PLAN PAGE
A.	All samples were not field tested for Total Hydrocarbons, Benzene, Toluene, Ethylbenzene, Xylene, Trichloroethylene, Tetrachloroethylene and Dichloroethylene.	2.3	2
B.	Other GC columns were used.	2.3	3
C.	Samples were injected to the GC using the same gas tight glass syringe in which samples were collected.	4.0	7
D.	During the first week of work one point calibration checks were conducted.	6.0	11
E.	The Photo Ionization Detector was eliminated at the beginning of the investigation.	2.3	3
F.	Calibration checks did not necessarily follow after each five samples sequence.	6.0	11
G.	The standard for 100 PPM of BTEX was not available at the start of the investigation.	8.2	13

RECOMMENDATIONS

The results for each day of work should be reported to include the calibration curve with the respective chromatograms and the chromatograms of each of the samples. All the deviations mentioned before should be explained in the final report. It is highly recommended that the Project Manager include all the statistical analyses and criteria used for data validation and the use and limitations of the results obtained as applicable.