WESTERN GEOLOGIC RESOURCES, INC.

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4/17/89

ALAMEDA COUNTY
DEPT. OF ENVIRONMENTAL HEALTH
HAZARDOUS MATERIALS

11 Apr 1989

Gil Wistar
Alameda County Environmental
-Health Department
470 27th Street, Rm 324
Oakland, CA 94612

Re: Workplan
Chevron SS #92582
Dublin, CA.
WGR 1-124.01

Dear Mr. Wistar:

Western Geologic Resources Inc. (WGR) has been retained by Chevron USA to provide site assessment and remediation services at Chevron service station #92582, located at the corner of Dublin Boulevard and Village Parkway in Dublin, California. (Figures 1 and 2).

BACKGROUND

WGR was originally contacted to sample tank backfill materials, excavate them and dispose of them properly. Standing water in the tank pit was removed by Erikson Trucking and disposed of at Gibson oil of Bakersfield, California. Hydrocarbon concentrations up to 1200 parts-per-million (ppm) total petroleum hydrocarbons (TPH) were found in the backfill material. At tank removal, 100 ppm TPH were found in the water in the tank pit. This concentration has been reduced to 19 ppm TFH, but benzene remains at 100 parts-per-billion (ppb).

lab results?

The work performed to date and the analytical results are described in detail in WGR's March 1989 Backfill Sampling, Excavation and Disposal Report. Briefly, tank backfill materials were sampled, excavated and disposed of properly. Sidewall samples and tank pit bottom samples were collected and analyzed. Sidewall samples indicated that material had been removed to below 100 ppm with the highest containing 29 ppm. Tank pit bottom samples indicated that material had been removed to below 10 ppm. The last sample was approximately 3 ppm.

Chevron's present goal is to gain permission for the present property owner to install tanks back into this tank pit and to put the station back into service as soon as possible. Further site investigation and/or remediation can and will proceed concurrent with site operation, under Chevron's direction.

FURTHER SITE ASSESSMENT/PRELIMINARY REMEDIATION

WGR will collect and review all previous reports and information available about the site. The information will be used to determine if there is a need for further drilling to obtain soil and water samples to better define the vertical and horizontal extent of hydrocarbons. The program will also determine the hydrocarbon concentrations in any contaminant plume that is identified. The WGR standard operating procedures for soil boring and sampling, groundwater monitoring well installation, and development and groundwater sampling are included as Attachments A and B and C, respectively.

The potential need for monitoring nearby wells has been identified in the tank pit area. To accomplish this, we propose the installation of two 10-inch diameter solid casings in the tank pit backfill. Figure 3 illustrates the procedure for use of blank casings. The casings will allow safe drilling through the tank backfill to monitor and/or recover groundwater directly under the tanks. After drilling and casing the well(s), the 10-inch casing(s) will be withdrawn two to five feet and the wells will be completed in the manner consistent with standard well installation procedures. These new wells will be used for groundwater monitoring directly below the tank pit and as potential recovery wells if offsite migration needs to be mitigated.

ANALYTIC LABORATORY AND ANALYSIS

Soil and groundwater samples that are collected will be sent to Central Coast Analytical Services (CCAS), a State-certified laboratory. The samples will be analyzed by EPA methods specified in the June 1988 *Regional Board Staff Recommendations For Initial Evaluations And Investigation Of Underground Storage Tanks.*

All soil samples selected for analysis will be analyzed by EPA Method 524.2 for total purgeable petroleum hydrocarbons (TPPH) and aromatic hydrocarbons, which include Benzene, Toluene, Ethyl-benzene and Xylenes (BTEX).

Water samples collected from the monitoring wells will be analyzed by EPA Method 534.2 for TPPH, aromatic hydrocarbons, and purgeable priority pollutants.

If our file review indicates the possible presence of hydrocarbons from a waste oil tank, the appropriate soil samples will be analyzed by EPA Method 524.2 for purgeable priority pollutants and both soil and water samples will be analyzed by EPA Method 503 for oil and grease and by Atomic Absorption for specific metals.

A discussion of the use of EPA Method 524.2 versus EPA Method 8015 is included as Attachment D.

SUMMARY

The objective of this work plan is to identify, assess and eventually mitigate all sources and remediate any impacts to soil and/or groundwater. The initial phase of the work will be aimed at determining the vertical and horizontal extent of vadose, saturated zone and dissolved contamination. Phases following this phase would be aimed at mitigating any off site migration of contaminants and finally remediating the site. This work will be performed in the most expeditious manner possible. At the same time, we will seek to minimize the impact of the work on site operations and local traffic.

We appreciate your timely review of this work plan, as we would like to begin our work as soon as possible. If you have any questions or comments, please call us at (415)457-7595.

Sincerely,
Western Geologic Resources, Inc.

Rudolph R. Millan, P.E.
Senior Engineer

Sherwood Lovejoy Jr.
President/Senior Hydrogeologist

cc: Robert Foss - Chevron
Diane White - RWQCB-S.F.Bay Region
Victor Taylor - City of Dublin

Figures:

Figure 1 :	Site Location Map
Figure 2 :	Site Plan
Figure 3 :	Proposed Casing and Well Installation

Attachments:
A-SOP 2-Soil Sampling Procedure
B-SOP 4-Well purging and Groundwater Sampling Procedure
C-SOP 3-Monitoring Well Installation and Development Procedure
D-"Characterization of Fuels and Fuel Spills", S. Havlicek of CCAS

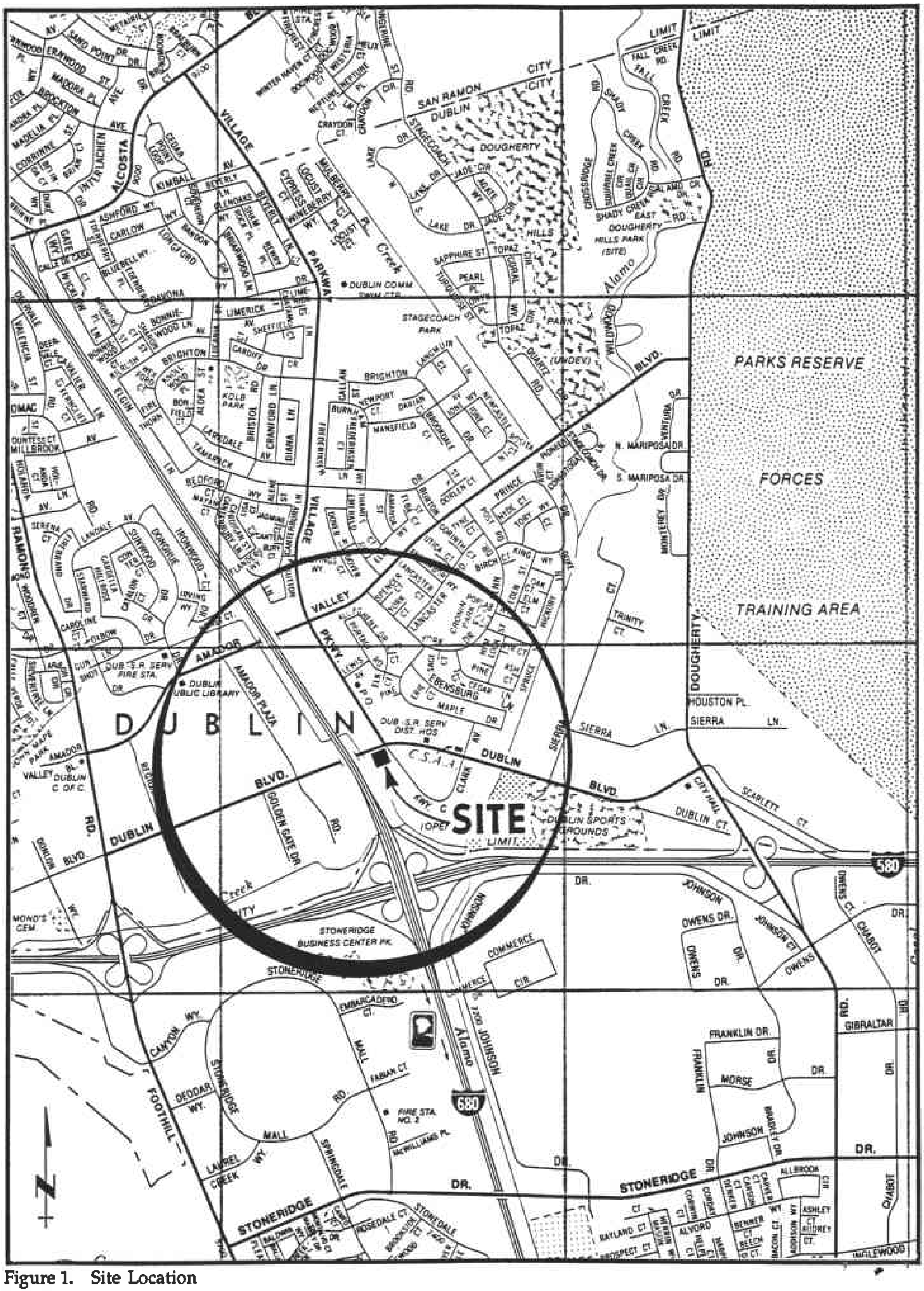
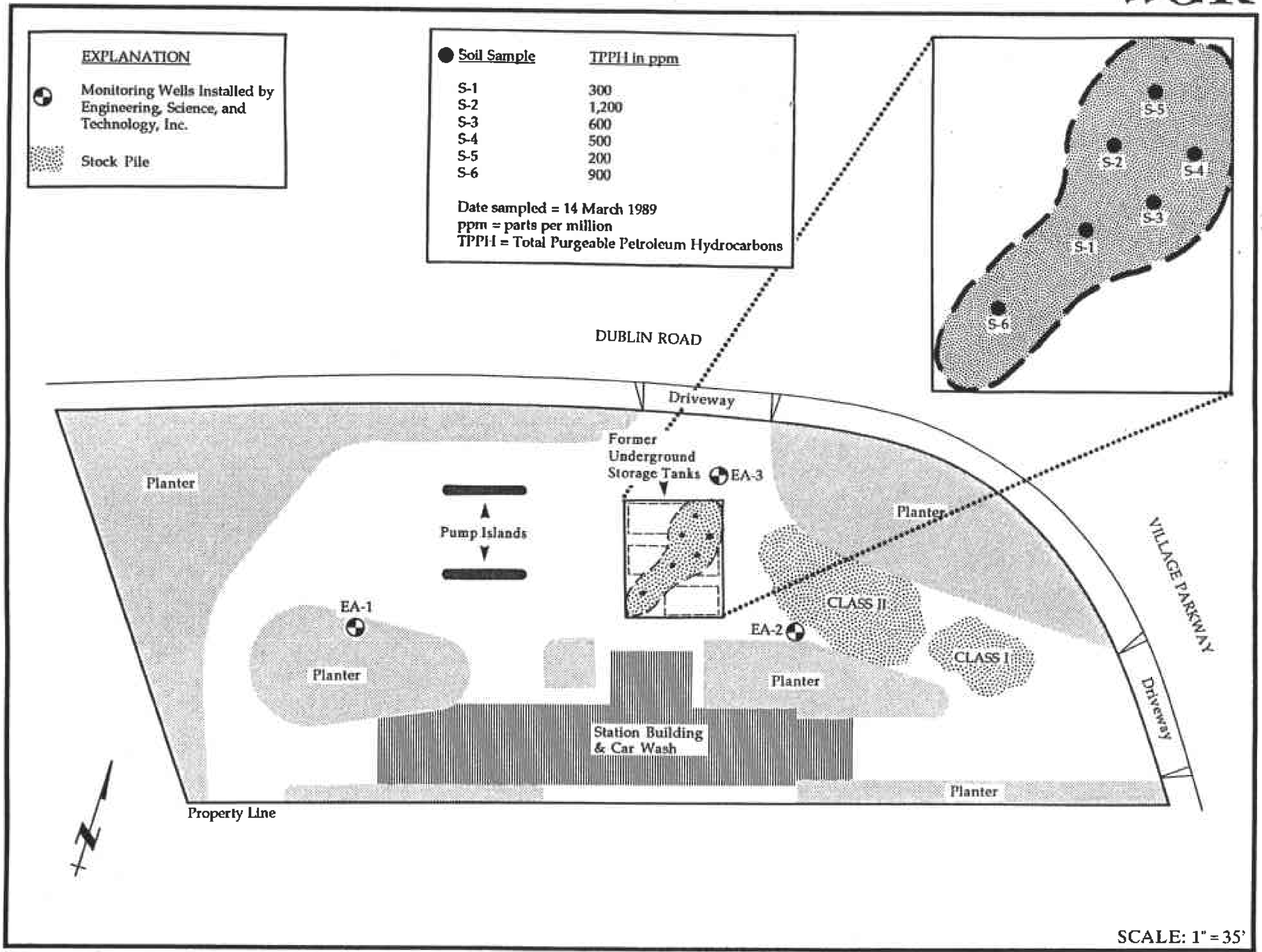


Figure 1. Site Location
Chevron SS #92582, Dublin, California.



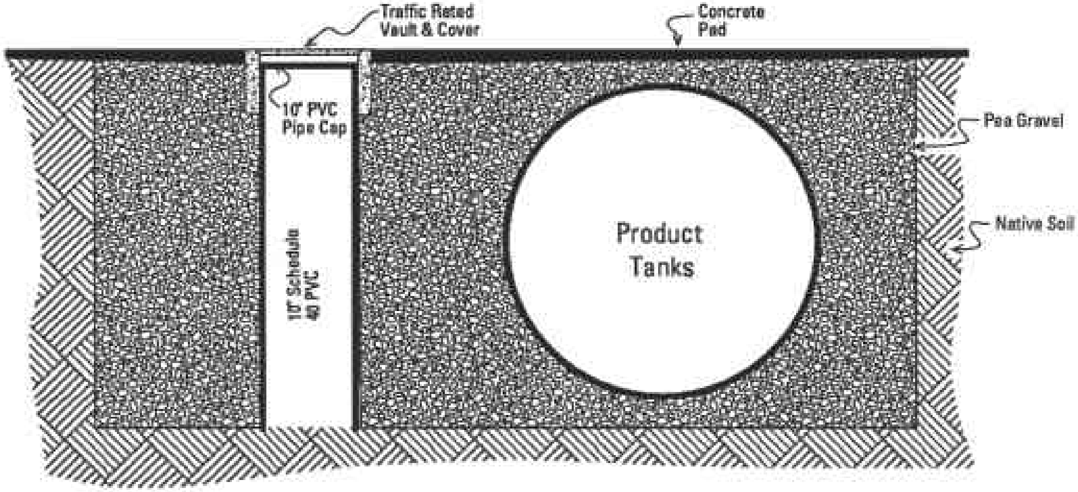
● Soil Sample	TPPH in ppm
S-1	300
S-2	1,200
S-3	600
S-4	500
S-5	200
S-6	900

Date sampled = 14 March 1989
ppm = parts per million
TPPH = Total Purgeable Petroleum Hydrocarbons

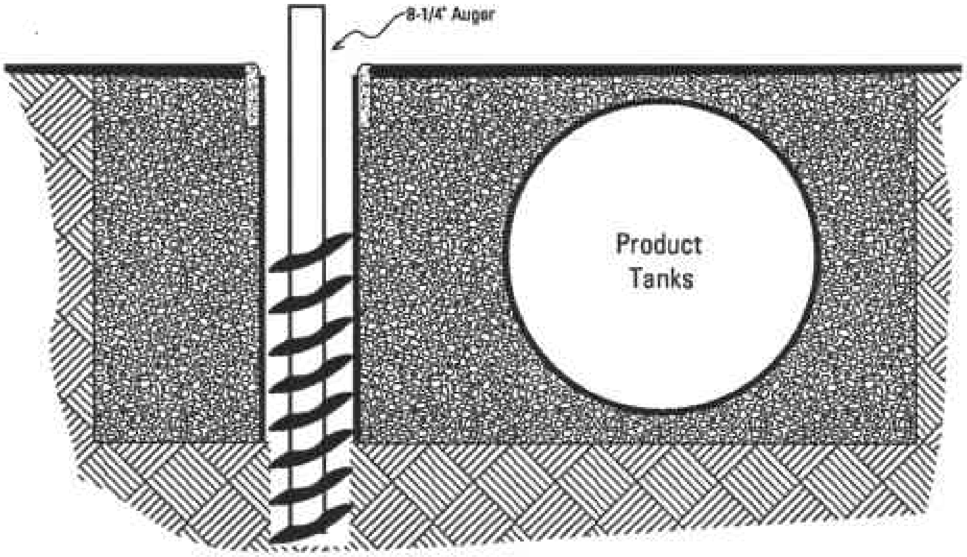
Figure 2. Site Map with Monitoring Well Locations and Stock Piles
Chevron SS #92582, Dublin, California.

Figure 3.

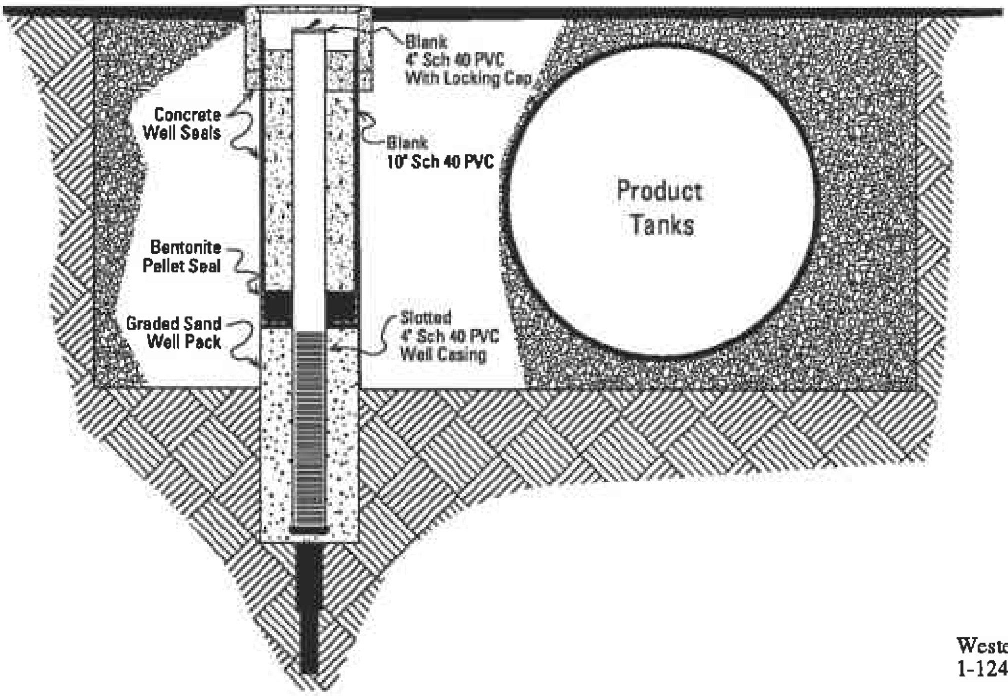
Step 1. Install Blank Casing During Tank Installation



Step 2. Drill Well Through Blank Casing



Step 3. Complete Well Within Casing



ATTACHMENT A

SOP-2: SOIL SAMPLING PROCEDURE

WESTERN GEOLOGIC RESOURCES, INC.
STANDARD OPERATING PROCEDURES
RE: SOIL SAMPLING
SOP-2

Soil samples for chemical analysis are collected in thin-walled brass tubes, 4-inches long by 2-inches outside diameter. Four of these tubes and a spacer tube are set in a 2-inch inside diameter 18-inch split-barrel sampler.

The split-barrel sampler is driven its entire length either hydraulically or using a 140-pound drop hammer. The sampler is extracted from the borehole and the brass tubes, containing the soil samples, are removed. Upon removal from the sampler, the selected brass tubes are immediately trimmed and capped with aluminum foil and plastic caps. They are then hermetically sealed with duct tape, labeled and refrigerated for delivery, under chain-of-custody, to the analytic laboratory. These procedures minimize the potential for cross-contamination and volatilization of volatile organic compounds (VOC) prior to chemical analysis.

One soil sample collected at each sampling interval is analyzed in the field using either a photoionization detector (PID), a flame ionizing detector (FID), or an explosimeter. The purpose of this field analysis is to qualitatively determine the presence or absence of hydrocarbons and to establish which soil samples will be analyzed at the laboratory. The soil sample is sealed in a zip-lock plastic bag and placed in the sun to enhance volatilization of the hydrocarbons from the sample. The data is recorded on the drill logs at the depth corresponding to the sampling point.

Other soil samples are collected to document the stratigraphy and estimate relative permeability of the subsurface materials. All drilling and sampling equipment are steam-cleaned prior to use at each site and between boreholes to minimize the potential for cross-contamination.

ATTACHMENT B

SOP-4: WELL PURGING AND GROUNDWATER SAMPLING PROCEDURE

WESTERN GEOLOGIC RESOURCES, INC.
STANDARD OPERATING PROCEDURES
RE: GROUNDWATER PURGING AND SAMPLING
SOP-4

Prior to water sampling, each well is purged by evacuating a minimum of three well-casing volumes of groundwater or until the discharge water temperature, conductivity, and pH stabilize. The groundwater sample should be taken when the water level in the well recovers to 80% of its static level.

The sampling equipment used consists of either a teflon bailer or a stainless steel bladder pump with a teflon bladder. If the sampling system is dedicated to the well, then the bailer is made of teflon, but the bladder pump is PVC with a polypropylene bladder. Forty milliliter (ml) glass volatile-organic-analysis (VOA) vials, with teflon septa, are used as sample containers.

The groundwater sample is decanted into each VOA vial in such a manner that there is a meniscus at the top of the vial. The cap is quickly placed over the top of the vial and securely tightened. The VOA vial is then inverted and tapped to see if air bubbles are present. If none are present, the sample is labeled and refrigerated for delivery under chain-of-custody to the laboratory. Label information should include a sample identification number, job identification number, date, time, type of analysis requested, and the sampler's name.

For quality control purposes, a duplicate water sample is collected for each well. This sample is held at the laboratory unless needed. A trip blank is prepared at the laboratory and placed in the transport cooler. It remains with the cooler and is analyzed by the laboratory along with the groundwater samples. A field blank is prepared in the field when sampling equipment is not dedicated. The field blank is prepared after a pump or bailer has been steam-cleaned, prior to use in a second well, and is analyzed along with the other samples. The field blank demonstrates the quality of in-field cleaning procedures to prevent cross-contamination.

To minimize the potential for cross-contamination between wells, all the well-development and water-sampling equipment that is not dedicated to a well is steam-cleaned between each well. As a second precautionary measure, wells will be sampled in order of least to highest concentrations as established by previous analyses.

ATTACHMENT C

SOP-3: MONITORING WELL INSTALLATION AND DEVELOPMENT PROCEDURE

WESTERN GEOLOGIC RESOURCES, INC.
STANDARD OPERATING PROCEDURES
RE: HOLLOW-STEM AUGER MONITORING WELL INSTALLATION AND DEVELOPMENT
SOP-3

The boreholes for monitoring wells are drilled using a truck-mounted hollow-stem auger drill rig. The outside diameter (OD) of the borehole will be a minimum of two inches larger than the casing OD when installing 4-inch well screen. The hollow-stem auger provides minimal interruption of drilling while permitting soil sampling at desired intervals. Soil samples are collected by hammering a conventional split-barrel sampler containing pre-cleaned 2-inch brass sample tubes. A geologist from Western Geologic Resources continuously logs each borehole during drilling and constantly checks drill cuttings for odors. The sampler is rinsed between samples and steam-cleaned with all other drilling equipment between borings to prevent cross-contamination.

Monitoring wells are cased with threaded, factory-perforated and blank Schedule 40 PVC. The perforated interval consists of slotted casing, generally 0.020-inch wide by 1.5-inch long slot size, with 42 slots per foot. A PVC cap is fastened to the bottom of the casing with stainless steel screws; no solvents or cements are used. Centering devices may be fastened to the casing to assure even distribution of filter material and grout within the borehole annulus. The well casing is thoroughly washed and steam-cleaned prior to installation.

After setting the casing inside the hollow stem, sand or gravel filter material is poured into the annular space to fill from the bottom of the boring to 1 foot above the perforated interval. A 1- to 2-foot thick bentonite plug is placed above this filter material to prevent grout from infiltrating down into the filter material. Neat cement, containing about 5% bentonite, is then tremied into the annular space from the top of the bentonite plug to the surface. A lockable PVC cap is placed on each wellhead. Traffic-rated Christy boxes are installed around the wellhead for wells in parking lots and driveways while steel stove pipes are usually set over wellheads in landscaped areas.

After installation, the wells are thoroughly developed to remove residual drilling materials from the wellbore, and to improve well performance by removing any fine material in the filter pack that can pass from the formation into the well. Well development techniques used include pumping, bailing, surging, swabbing, jetting, flushing, and airlifting. All development water is collected in 55-gallon drums for temporary storage, and is then disposed of properly depending on analytic results. To assure that cross-contamination does not occur between wells during drilling and development, all development equipment is steam-cleaned.

ATTACHMENT D

"CHARACTERIZATION OF FUELS AND FUEL SPILLS"

S. HAVLICHEK OF CCAS

CHARACTERIZATIONS OF FUELS AND FUEL SPILLS

by

Stephen C. Havlicek, Ph.D.
Vice President
CENTRAL COAST ANALYTICAL SERVICES, INC.
August 1988

INTRODUCTION

Hydrocarbon distillates, residuums and crude oils are items of commerce and therefore have a significant opportunity for release into the environment. The first section of this document begins with a definition of some of the hydrocarbon products in commercial use. The second section discusses changes in the composition of hydrocarbon materials upon release into the environment while the third section describes sampling and analytical considerations.

DEFINITIONS

Gasoline is a mixture of low boiling hydrocarbons suitable for use in a spark-ignited internal combustion engine and having an octane rating of at least 60. Major components are branched chain saturated hydrocarbons, alicyclic hydrocarbons, and aromatic hydrocarbons. Over 200 individual gasoline components may be separated from one another during a high resolution gas chromatographic analysis. The typical hydrocarbon range is C-4 through C-12. Unleaded gasolines often have a higher proportion of aromatic hydrocarbons than do leaded gasolines. Aviation gasolines have a higher octane than do automotive gasolines and therefore often contain a still higher proportion of aromatics. Tetraethyl and tetramethyl lead are added to leaded gasoline in order to boost the octane. If these additives are used as octane boosters, ethylene dibromide and/or ethylene dichloride are often added to promote removal of the lead from the engine. Methyl t-butyl ether (MTBE) is now preferred as an octane booster because it does not contain any lead. Benzene, toluene, ethylbenzene and xylene (BTX or BTX & EB) are major components which are of special environmental interest. Appendix H from the Leaking Underground Fuel Tank (LUFT) field manual provides a detailed list of the components of a typical gasoline.

Diesel #2 (automotive diesel) is comprised chiefly of unbranched saturated hydrocarbons together with minor amounts of alicyclics, unsaturates and some aromatic hydrocarbons. It is a straight-run or cracked petroleum distillate with a typical hydrocarbon range of C-8 through C-27. It is used in atomizing burners which spray the fuel into a combustion chamber where the tiny droplets burn while in suspension. BTX & EB are minor components but can nevertheless reach levels of concern as dissolved components in groundwater which has been in contact with Diesel #2. An in-house listing of typical hydrocarbon components is appended.

Diesel #4 (railroad diesel) is a higher boiling straight-run or cracked petroleum distillate with a typical hydrocarbon range of C-11 through C-30. It is used in commercial or industrial burner installations not requiring preheating but having a design which accommodates the higher viscosity of Diesel #4. Like Diesel #2, the major hydocarbon components are unbranched paraffins, together with lesser amounts of alicyclics and polynuclear aromatic hydrocarbons (PNAs). An in-house listing of individual components is appended.

Diesel #5 is a residual fuel rather than a distillate and often requires preheating for burning. In colder climates it may require preheating for handling. Straight chain hydrocarbons dominate.

Diesel #6 is a heavier residual fuel sometimes known as Bunker C. It is a high viscosity oil used in commercial and industrial heating. It requires preheating in both the storage tank and at the burner and is therefore used only in large volume applications. Sulfur-containing organics, unless deliberately removed, are found in larger proportions in the residul fuels than they are in the distilled fuels.

Stoddard Solvent is a petroleum distillate widely used as a dry cleaning solvent. It is composed of a narrow range of saturated hydrocarbons (85 percent) with the nonanes dominating. The remaining 15 percent is composed of a narrow range of alkylbenzenes with the C-3 alkylbenzenes dominating. Recent toxicological concerns have caused the maximum percent benzene allowed to be lowered from 2 to less than 0.02. Other narrow petroleum fractions in this range which are sometimes used interchangeably for dry cleaning purposes may have different proportions of aliphatics and aromatics. It is sometimes called light petroleum naphtha. A typical boiling range is 220-300^F. Under some conditions, it is possible for groundwaters in contact with Stoddard solvent to develop objectionable levels of BTX.

Jet Fuels are light petroleum distillates similar to kerosine. They are available in several forms depending on the type of jet engine in which it is intended to be used. JP-1, JP-4, JP-5 and JP-6 are military grades having flash points of 95^F, -10^F, 95^F and 100^F respectively. JP-4 is roughly equivalent to commercial Jet B and is a mixture of 65 percent gasoline and 35 percent light petroleum distillate. JP-5 is a specially refined kerosine having a low freezing point and a relatively high flashpoint. These properties make it preferable for use by carrier based aircraft. JP-6 is a slightly higher cut with fewer impurities and is used in more advanced engines. Jet A and Jet A-1 are commercial kerosine fuels resembling JP-6 and JP-5 respectively. A-1 is preferred for long range flights while A is preferred for short and medium range flights.

CHANGES IN FUEL COMPOSITION UPON RELEASE TO THE ENVIRONMENT

The relative proportions of fuel components discharged to the environment will be changed due to volatilization, differential solubility in water, differences in biodegradation rates and relative affinities for soil components. Volatile components such as propanes, butanes, pentanes and hexanes will have a stronger tendency to be lost from surface spills because they have a higher vapor pressure than other fuel components. Lighter fuel components as shown in TABLE I have a greater solubility in water than do heavier components. Accordingly, these will be preferentially stripped away as rainwater moves through hydrocarbons spilled in the vadose zone on its way to become groundwater. Thus the vadose zone will be depleted in lighter fractions relative to the original fuel while the groundwater will be enriched. Similarly, unsaturated and cyclic components are more soluble than their straight chain and saturated counterparts. For example, the solubility of butene is more than three times larger than that of butane while the solubility of both hexene and cyclohexane are more than four times larger than that of hexane. Aromatics exhibit even larger increases in solubility relative to the corresponding aliphatics. For example, benzene is more than 100 times as soluble as hexane. Thus gasoline fractions remaining in the vadose zone lose their light ends and aromatics and begin to resemble diesel #2. Diesel #2 fractions dissolving in groundwater become enriched in light ends and aromatics and therefore begin to resemble gasoline. In order to properly identify fuel types in the environment it is necessary to take these factors into account.

The issue of changes in fuel composition upon release to the environment is further complicated by the differences in affinity which fuel components have for soils. In general, organic-rich soils and finer soils will retard the movement of fuel components more strongly than organic-poor and coarser soils. Retardation of dissolved fuel components by fine soils is not to be confused with the tendency of free product to gather in coarse soil lenses which is a function of free volume rather than the tendency of the product to adhere to the soil. Since the affinities of fuel components for soil and soil organics are often the reverse of their solubilities, the selective differentiation of these components according to solubility is further accentuated by their relative retardation by the soils into which they have been released.

Biodegradation rates are also strongly influenced by molecular structure. In general, straight-chain saturated hydrocarbons are degraded more readily than aromatics which, in turn, are degraded more readily than alicyclics and highly branched aliphatic hydrocarbons. Since much of this biodegradation takes place in the vadose zone, contaminated soils are often enriched in alicyclics and highly branched aliphatics relative to the hydrocarbon product which was the source of the spill. Alkylaromatics such as toluene can be biochemically degraded either by attack on the ring to produce 3-methylcatechol or by successive oxidation of the side chain to produce benzyl alcohol, benzaldehyde, benzoic acid and then catechol. p-Xylene undergoes a similar stepwise biodegradation to produce 4-methylbenzyl alcohol, 4-methylbenzaldehyde, p-toluic acid and 4-methylcatechol. Aerobic biodegradation can often be enhanced when sampling exposes oxygen-poor groundwaters to the atmosphere. It is therefore very important to properly preserve groundwater samples containing hydrocarbons.

TABLE I
Solubility of Selected Hydrocarbons in Water

Component	Solubility in ppm
Methane	25
Ethane	59
Propane	63
Butane	61
Pentane	35
Hexane	13
Heptane	3
Octane	0.66
Nonane	0.07
Decane	0.008
Ethylene	131.
Proplylene	200.
Butene	210.
Pentene	150.
Hexene	50.
Heptene	9.
Octene	2.6
Cyclohexane	55.
Benzene	1780.
Toluene	550.
o-Xylene	175.
p-Xylene	198.
Ethylbenzene	152.
Propylbenzene	60.
Isopropylbenzene	50.
Naphthalene	30.
Methylnaphthalene	27.
Anthracene	1.3
Phenanthrene	1.3
Pyrene	0.16
Fluorene	1.9
Fluoranthene	0.27
Methylcyclohexane	14.

Solubilities are somewhat diminished by the presence of components of like properties whereas components of a different chemical nature have been shown to enhance solubilities. Thus gasoline without any additives would be expected to have an overall solubility which was considerably less than the sum of the individual solubilities. Methyl tertiary butyl ether MTBE, methanol and ethanol are added to gasoline to improve the octane rating and/or to improve the tolerance for moisture. While MTBE appears to have little influence on the water solubility of other gasoline components, both methanol and ethanol provide considerable enhancements.

SAMPLING AND ANALYTICAL CONSIDERATIONS

Fuels are highly complex mixtures of hydrocarbons which often contain more than a hundred identifiable components. Gasolines are characterized by their lower boiling range and by their aliphatic and aromatic hydrocarbon distributions. These, together with the presence or absence of lead and ethylene dibromide and/or ethylene dichloride serve to distinguish between leaded and unleaded gasoline. CENTRAL COAST ANALYTICAL SERVICES, INC., has modern instrumentation which can separate and simultaneously identify the type of fuel, the amount present, and the BTX . Further, ethylbenzene, ethylene dibromide and ethylene dichloride, which are added to leaded gasoline, are also separated and quantatively identified.

CENTRAL COAST ANALYTICAL SERVICES, INC., provides septum sealed vials free of charge to clients interested in collecting their own groundwater samples for fuel fingerprint analysis. These vials contain an ASTM-approved preservative which adjusts the pH to 2 in order to block biodegradation which can otherwise be a very serious factor. Soils are best sampled using metallic Shelby tubes or brass rings and then covering the ends of the tubes with Teflon sheeting prior to emplacing a snugly-fitting plastic cap. The whole core is frozen or refrigerated in the field. Once in the laboratory, subsamples may be removed and analyzed by a variation of the purge-and-trap gas chromatographic technique. Although it is unlikely that significant loss takes place if the samples are frozen, the holding time for volatile compounds in soil is 14 days from time of sampling until the time the sample is analyzed.

Water samples are collected by completely filling the vials, sealing, checking for bubbles and refilling and resealing if bubbles are present, then placing the filled vials into plastic guard bottles which contain activated charcoal. The guard bottles which contain the charcoal are refrigerated (NOT FROZEN) in the field. Analysis is performed using EPA Method 524.2 and compared to standards containing appropriate fuels and volatile Priority Pollutants.

When free product is available, some of that should be sampled and submitted in a septum-sealed vial which is then placed in a guard bottle. The laboratory should be instructed to use the free product for the standard used to quantitate the fuel in the samples.

During the initial stages of an investigation, it is recommended that samples be taken at several depths to groundwater. If it is unclear whether or not groundwater has been contaminated, we recommend drilling be stopped if strong petroleum odors are encountered. In the later stages of an investigation, drilling may be continued in such cases PROVIDED that precautions are taken to ensure that contamination will not follow the path of the drill as it passes through the contaminated zone.

Oversampling followed by selected sample analysis is recommended. This strategy allows the laboratory to zero in on meaningful samples while avoiding costly resampling. CENTRAL COAST ANALYTICAL SERVICES, INC. employs both flame ionization (FID) gas chromatography and selected ion GC/MS to obtain fuel fingerprints. We prefer the latter since it gives information about the distribution of aliphatic and aromatic hydrocarbons which is not available by

FID. Both techniques are sufficiently sensitive to detect spilled fuels at sub part per million levels.

COMMENTS REGARDING EPA METHODS 8015, 8020, 8240 & 8270

EPA apparently has included this method in SW-846 to provide guidance for the determination of potentially hazardous materials which do not respond well to electron-capture detection (ECD), photoionization detection (PID) or halogen-selective detection (HALL). Since the flame ionization detector (FID) employed by EPA 8015 is both sensitive and non-selective, most organic compounds listed will produce a strong signal. Therefore, acrylamide, carbon disulfide, diethyl ether, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and paraldehyde which are the compounds listed in EPA 8015 can readily be detected using this method. Furthermore, the FID is sufficiently nonselective to permit extension of the method to a host of other materials.

In many commercial laboratories, fuels are determined by pattern comparison using gas chromatography with flame ionization detection (GC/FID) using an adaptation of EPA Method 8015. Samples containing volatile analytes may be introduced to the gas chromtograph by direct injection, headspace (EPA Method 5020) or purge-and-trap (EPA Method 5030). When used in this way, EPA Method 8015 can be used to characterize gasoline, diesel #2, jet fuel, aviation gas, Stoddard solvent and other volatile hydrocarbon distillates. The results may be expressed in terms of "ppm gasoline", "ppm total petroleum hydrocarbon (TPH)" or some other appropriate description. The analysis is described as a "TPPH (Total Purgeable Petroleum Hydrocarbon Analysis)", a "fuel characterization analysis", or a "fuel fingerprint". A column substitution is usually made as even the volatile fuels contain some components requiring temperatures beyond the maxima permitted for the columns specified in EPA Method 8015.

When semivolatile fuels or analytes are to be determined, the FID and EPA Method 8015 may still be employed. In such cases, the sample may be introduced by direct injection, prepared for analysis by liquid-liquid extraction (EPA Method 3510), sonication (EPA Method 3550) or Soxhlet extraction (EPA Method 3540). Following extract concentration, an aliquot of the concentrate is subjected to gas chromatographic separation followed by flame ionization detection. This variation of EPA Method 8015 is often used for the analysis of diesel #4, crude oil, bunker fuel and fuel oil #6. It is sometimes used for the analysis of diesel #2 and even gasoline, although much of the gasoline components are lost during the concentration step. This type of analysis is often described as a TPH (Total Petroleum Hydrocarbon analysis). When doing this type of analysis, CCAS refers to the results as Total Semivolatile Petroleum Hydrocarbons and lists the fuel used as a standard for quantifying the material. CCAS uses standards which are provided by the client or which resemble the samples' chromatographic pattern.

While CCAS is capable of performing all of the aformentioned variations of EPA 8015, our recommended approaches to the analysis of nonhalogenated volatile organics, volatile fuels and in some cases, even semivolatile fuels are based upon GC/MS as outlined in EPA Methods 524.2, 8240 and 8270. If techniques such as cryogenic focussing, selected ion monitoring, capillary column chromatography and direct column-to-mass spectrometer source interfacing are incorporated into the basic EPA protocols, the required 1 ppb sensitivities can be reached easily. Since the mass spectrometer is the most selective detector available, interferences and misassignments are reduced dramatically. CCAS has applied GC/MS successfully to all of the six compounds listed in EPA Method 8015. Detection limits of 0.1 ppb have been obtained without using selective ion monitoring. These results are on file with the California Department of Health Services (Hazardous Waste Certification and Drinking Water Certification Branches).

At the time at which EPA methods were being developed, economical, automated GC/MS instrumentation was not widely available. For this reason, GC/MS was considered to be too costly to serve as a practical alternative to EPA Method 8015 and such selective detector methods as EPA 8010 and 8020. Recently, instrument costs have fallen to the point that a GC/MS system can be purchased for little more than double that of a comparable gas chromatograph. Moreover, positive results obtained using selective detection gas chromatography are subject to confirmation using another column (rerunning the test again) or by using GC/MS. Practical improvements in automation have further improved the cost-effectiveness of GC/MS so that some jobs can now be done more economically by GC/MS than by GC, particularly when confirmation is necessary.

For example, the analysis of soils adjacent to a leaking gasoline tank should include a fuel fingerprint to determine the fuel type and the total petroleum hydrocarbons (TPH) and EPA Method 8020 to quantify the benzene, toluene, and xylene (BTX) levels. Furthermore, if leaded fuel is suspected, ethylene dibromide (EDB) and ethylene dichloride (EDC) should be determined as these compounds are often added to gasoline to promote the removal of lead from the engine following combustion. EDB is a priority pollutant which is analyzed by EPA Method 8080.1. CCAS has selected those ions which are characterisic of the aformentioned components from among the ions available in the full scan EPA Methods 524.~~1~~2 and 624/8240. In this way we are able to determine simultaneously the most commonly requested information concerning volatile hydrocarbons in the environment. Furthermore, the cost for this analysis at $135 in water and $155 in soil is substantially below the sum of the three separate analyses which would otherwise be required, namely, EPA 8015 @ $75/100, EPA 8020 @ $90/120 and EPA 8080.1 @ $75/100. Moreover, confirmation testing is not required when using GC/MS since it is the method recommended by EPA for confirmation. Furthermore, the use of internal standards is possible and thereby provides a significant quality assurance advantage to the method. Additional compounds such as TCA, TCE and PCE which are often used at service stations and sometimes discharged to faulty waste oil tanks can be added to the program by special request. The additional cost for this addition is not large and allows all aspects of the investigation to be handled with a single analysis. Thus it can be seen that GC/MS provides better information at a lower overall price.

The GC/MS fuel fingerprint method has been shown to provide even more detailed information in cases in which depth and/or area profiles are involved. Typically, one sees a distribution of fuel components with depth which dramatically changes itself once groundwater is reached. EDB, for example, may be found only at the groundwater interface due to its preferential solubility in water. Heavier, biorefractory components are retained by the soil nearer the surface while more mobile components are found at depth. Information of this type serves to validate all sample results obtained in the course of a major investigation using GC/MS methods, yet it is very difficult to obtain all of these data using only EPA Method 8015.

If a gasoline spill is suspected, we recommend analysis for total lead as well as the fuel fingerprint. High levels of lead compared to background samples, even in the absence of a fuel fingerprint, may indicate that gasoline was spilled in the area but has become degraded by soil microorganisms. This phenomenon is sometimes noted in nearsurface samples. In the event that elevated lead levels are found, a second general analysis for organic lead or a specific analysis for tetraethyl and tetramethyl lead can be requested if the regulator so desires. Typically only a very low percentage of the total lead is found to be organic lead. Even this is most often found to be associated with fulvic and humic matter as chelated inorganic lead. It is our experience that only a few isolated cases actually involve organic lead in a non-chelated form.

The procedures used by CCAS for spilled fuel characterization have been submitted to and reviewed by the California Department of Health Services and by the California Water Quality Control Board. A memorandum from Gordon Lee Boggs, Underground Tank Program Coordinator for the California Central Valley Regional Water Quality Control Board refers to CCAS' GC/MS method. Three pages from this memorandum are attached.

Memorandum

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD • CENTRAL VALLEY REGION
3443 Routier Road
Sacramento, California 95827-3098
Phone: (916) 361-5600
ATSS: 8-495-5600

TO: Supervisors and Seniors
all offices

FROM: Gordon Lee Boggs
Underground Tank
Program Coordinator

DATE: 4 April 1988

SIGNATURE:

SUBJECT: SAMPLING PROCEDURES, MINIMUM VERIFICATION ANALYSES AND REPORTING REQUIREMENTS FOR SOIL AND GROUND WATER CONTAMINATION RESULTING FROM LEAKING UNDERGROUND STORAGE TANKS (LUST)

Over the past few years we have been working with Local Implementing Agencies (LIAs), other Regional Boards and the State Board to develop consistent guidelines for tank owners to follow when cleaning up LUST sites. Within the next few months the Leaking Underground Fuel Tank (LUFT) technical document, of which I am part author, will be distributed to the public. LUFT is an initial step on a state-wide basis to provide some guidance.

Attached to this memo are procedures (summarized below) developed to supplement and expand on LUFT which is limited primarily to soils contaminated by motor vehicle fuels and does not address situations which many LIAs and Regional Board regulatory staff often face. The procedures were developed independently in several regions and have been reviewed by representatives of the LIAs. As recurring problems are found at different sites, it will become necessary to develop procedures which identify minimum requirements for the regulated sites. Because the procedures have been developed to fit a flexible and evolving program, they are subject to site-specific interpretation.

The information in the attachments has been submitted to the LUFT Final Document committee, and the latest draft shows that some procedures, as applicable, have been incorporated.

SOIL SAMPLING

As the attached draft chart shows, the sampling procedures follow the current State Regulations, Subchapter 16 and a consensus of the participants for what will provide the maximum information for the least bucks spent.

MINIMUM VERIFICATION ANALYSIS

The Minimum Verification Analysis (MVA) procedures were developed from the experience of the Regional Boards and LIAs. They are intended of contamination lies and when the cleanup levels are attained (low level analyses). To assure that a site definition is comprehensive, it is recommended that the Minimum Verification Analyses (MVA) listed in Table 1 be conducted as needed to determine the extent of contamination.

Laboratory Methodologies and MVA Costs

We have conducted a survey of 65 DHS certified laboratories in California and found that there is wide variation in methodologies for analysis of Total Petroleum Hydrocarbons (TPH) and Benzene, Toluene, Xylene, and Ethylbenzene (BTX&E). Some differences include sample size and preparation, solvents, columns and detectors used and lapses in quality assurance. Although these variations currently account for the differences in the ability for laboratories to report consistent, detectable levels of the compounds, the Regional Boards are working with the laboratories and State agencies to resolve this by developing consistent guidelines and protocol. The intent is to produce and encourage innovative and more precise protocol which will provide more reliable data to the tank owner and regulatory agencies. As shown in the cost/analysis table below, labs have routine analyses but can lower their detection limits by improving protocol.

For instance, one laboratory in California uses a modified EPA approved 524.2 (and 8240) methodology (GCMS procedure) to produce exceptionally low and accurate detection levels for both TPH and BTX&E at a little more than half the price of the two combined. The method (focused cryogenics) uses liquid argon to freeze the chemicals prior to injection into the detector. This effectively eliminates interfering gases such as oxygen and allows the injection of 100% of the sample into the Mass Spectrometer for analysis (as opposed to approximately 10% by the conventional purge and trap procedure). The increased sample size provides accurate detection and, because it analyzes everything at once, lowers the cost of analysis considerably. Other advantages are that EDB also is identified and second column confirmation is not needed.

In the cost/analysis table the costs are based on submittal of a rather uncomplicated sample. Laboratory handling and preparation for "dirty" or complex samples may increase costs up to 30%, and consultants may add a 15% surcharge for collecting and transporting the sample, and interpreting the results. Therefore, a bill for BTX&E in soil may include $105 for the analysis + $35 for special work + $20 consultant fee thereby totalling $160 (or more). This may not be unreasonable for the circumstances.

Higher laboratory costs do not reflect the ability for the laboratory to provide more accurate work. Accuracy is dependent upon several things including proper quality assurance and control of the sample, instrument capabilities, personnel experience, etc. For instance, based on our experience, one of best, and consistently accurate, labs in the state has charges at the mean cost for the analyses below.

COST/ANALYSIS TABLE

ANALYSIS	COST			ANALYTICAL MEAN ppb	
	Range	Mean	Median	Routine	Improved
BTX&E					
Water (602)	$60-$150	$105	$105	0.5	0.5
Soil (8020)	$65-$170	$117	$120	60	40
TPH					
Gasoline					
Water (GCFID)	$50-$150	$100	$100	500	170
Soil (GCFID)	$60-$185	$107	$110	3600	1000
Diesel					
Water (GCFID)	$50-$150	$103	$100	960	250
Soil (GCFID)	$60-$185	$111	$110	5700	2600
Cryofocus (GCMS)					
Water-BTX&E+TPH	$135			0.1	0.1
Soil---BTX&E+TPH	$155			100	100

SOIL CONTAMINATION PROBLEMS

Once a tank has been removed, there may be significant soil problems which can not be resolved by a "scoop and run" cleanup of minor overspills but remain to be identified and remediated. To pursue a successful soil remediation plan, the lateral and vertical extent of soil contamination must be defined. Following are summaries of reports to answer the question "What reporting is required for the tank owner, when only soil is believed to be impacted and there is no apparent threat to ground water?" Two reports should provide information for both the tank owner and the LIA to reach a decision about the site. They are a

APPENDIX H

CHEMICAL COMPOSITION OF GASOLINE

Compound	Number of Carbons	Concentration (Weight Percent) (a)	Reference
Straight Chain Alkanes			
Propane	3	0.01 - 0.14	8,10
n-Butane	4	3.93 - 4.70	8,10,11
n-Pentane	5	5.75 - 10.92	8,10,11
n-Hexane(d)	6	0.24 - 3.50	8,10,11
n-Heptane	7	0.31 - 1.96	10,11
n-Octane	8	0.36 - 1.43	10
n-Nonane	9	0.07 - 0.83	10
n-Decane	10	0.04 - 0.50	10
n-Undecane	11	0.05 - 0.22	10
n-dodecane	12	0.04 - 0.09	10
Branched Alkanes			
Isobutane	4	0.12 - 0.37	8,10
2,2-Dimethylbutane	6	0.17 - 0.84	10
2,3-Dimethylbutane	6	0.59 - 1.55	8,10,11
2,2,3-Trimethylbutane	7	0.01 - 0.04	10
Neopentane	5	0.02 - 0.05	10
Isopentane	5	6.07 - 10.17	8,10,11
2-Methylpentane	6	2.91 - 3.85	8,10,11
3-Methylpentane	6	2.4 (vol)	8,10,11
2,4-Dimethylpentane	7	0.23 - 1.71	8,10,11
2,3-Dimethylpentane	7	0.32 - 4.17	8,10,11
3,3-Dimethylpentane	7	0.02 - 0.03	10
2,2,3-Trimethylpentane	8	0.09 - 0.23	10,11
2,2,4-Trimethylpentane	8	0.32 - 4.58	8,10
2,3,3-Trimethylpentane	8	0.05 - 2.28	10
2,3,4-Trimethylpentane	8	0.11 - 2.80	10,11
2,4-Dimethyl-3-ethylpentane	9	0.03 - 0.07	10
2-Methylhexane	7	0.36 - 1.48	10
3-Methylhexane	7	0.30 - 1.77	10,11
2,4-Dimethylhexane	8	0.34 - 0.82	10
2,5-Dimethylhexane	8	0.24 - 0.52	10
3,4-Dimethylhexane	8	0.16 - 0.37	10
3-Ethylhexane	8	0.01	10
2-Methyl-3-ethylhexane	9	0.04 - 0.13	10
2,2,4-Trimethylhexane	9	0.11 - 0.18	10

Compound	Number of Carbons	Concentration (Weight Percent) (a)	Reference
2,2,5-Trimethylhexane	9	0.17 - 5.89	10
2,3,3-Trimethylhexane	9	0.05 - 0.12	10
2,3,5-Trimethylhexane	9	0.05 - 1.09	10
2,4,4-Trimethylhexane	9	0.02 - 0.16	10
2-Methylheptane	8	0.48 - 1.05	10
3-Methylheptane	8	0.63 - 1.54	10
4-Methylheptane	8	0.22 - 0.52	10
2,2-Dimethylheptane	9	0.01 - 0.08	10
2,3-Dimethylheptane	9	0.13 - 0.51	10
2,6-Dimethylheptane	9	0.07 - 0.23	10
3,3-Dimethylheptane	9	0.01 - 0.08	10
3,4-Dimethylheptane	9	0.07 - 0.33	10
2,2,4-Trimethylheptane	10	0.12 - 1.70	10
3,3,5-Trimethylheptane	10	0.02 - 0.06	10
3-Ethylheptane	10	0.02 - 0.16	10
2-Methyloctane	9	0.14 - 0.62	10
3-Methyloctane	9	0.34 - 0.85	10
4-Methyloctane	9	0.11 - 0.55	10
2,6-Dimethyloctane	10	0.06 - 0.12	10
2-Methylnonane	10	0.06 - 0.41	10
3-Methylnonane	10	0.06 - 0.32	10
4-Methylnonane	10	0.04 - 0.26	10
Cycloalkanes			
Cyclopentane	5	0.19 - 0.58	8,10
Methylcyclopentane	6	Not quantified	8
1-Methyl-cis-2-ethylcyclopentane	8	0.06 - 0.11	10
1-Methyl-trans-3-ethylcyclopentane	8	0.06 - 0.12	10
1-Cis-2-dimethylcyclopentane	7	0.07 - 0.13	10
1-Trans-2-dimethylcyclopentane	7	0.06 - 0.20	10
1,1,2-trimethylcyclopentane	8	0.06 - 0.11	10
1-Trans-2-cis-3-trimethylcyclopentane	8	0.01 - 0.25	10
1-Trans-2-cis-4-trimethylcyclopentane	8	0.03 - 0.16	10
Ethylcyclopentane	7	0.14 - 0.21	10
n-Propylcyclopentane	8	0.01 - 0.06	10
Isopropylcyclopentane	8	0.01 - 0.02	10
1-Trans-3-dimethylcyclohexane	8	0.05 - 0.12	10
Ethylcyclohexane	8	0.17 - 0.42	10

Compound	Number of Carbons	Concentration (Weight Percent) (a)	Reference
Straight Chain Alkenes			
cis-2-butene	4	0.13 - 0.17	10
trans-2-butene	4	0.16 - 0.20	10
Pentene-1	5	0.33 - 0.45	10
cis-2-pentene	5	0.43 - 0.67	8,10
trans-2-pentene	5	0.52 - 0.90	10,11
cis-2-hexene	6	0.15 - 0.24	10
trans-2-hexene	6	0.18 - 0.36	10
cis-3-hexene	6	0.11 - 0.13	10
trans-3-hexene	6	0.12 - 0.15	10
cis-3-heptene	7	0.14 - 0.17	10,11
trans-2-heptene	7	0.06 - 0.10	10
Branched Alkenes			
2-Methyl-1-butene	5	0.22 - 0.66	8,10,11
3-Methyl-1-butene	5	0.08 - 0.12	10
2-Methyl-2-butene	5	0.96 - 1.28	8,10,11
2,3-Dimethyl-1-butene	6	0.08 - 0.10	10
2-Methyl-1-pentene	6	0.20 - 0.22	10,11
2,3-Dimethyl-1-pentene	7	0.01 - 0.02	10
2,4-Dimethyl-1-pentene	7	0.02 - 0.03	10
4,4-Dimethyl-1-pentene	7	0.6 (vol)	11
2-Methyl-2-pentene	6	0.27 - 0.32	10,11
3-Methyl-cis-2-pentene	6	0.35 - 0.45	10
3-Methyl-trans-2-pentene	6	0.32 - 0.44	10
4-Methyl-cis-2-pentene	6	0.04 - 0.05	10
4-Methyl-trans-2-pentene	6	0.08 - 0.30	10
4,4-Dimethyl-cis-2-pentene	7	0.02	10
4,4-Dimethyl-trans-2-pentene	7	Not quantified	10
3-Ethyl-2-pentene	7	0.03 - 0.04	10
Cycloalkenes			
Cyclopentene	5	0.12 - 0.18	10
3-Methylcyclopentene	6	0.03 - 0.08	10
Cyclohexene	6	0.03	10
Alkyl Benzenes			
Benzene(d)	6	0.12 - 3.50	6,7,8,9,10,11,12

Compound	Number of Carbons	Concentration (Weight Percent) (a)	Reference
Toluene(d)	7	2.73 - 21.80	5,6,7,8, 9,10,11, 12
o-Xylene(d)	8	0.68 - 2.86	6,9,10, 12
m-Xylene(d)	8	1.77 - 3.87	10
p-Xylene(d)	8	0.77 - 1.58	10
1-Methyl-4-ethylbenzene	9	0.18 - 1.00	10
1-Methyl-2-ethylbenzene	9	0.19 - 0.56	6
1-Methyl-3-ethylbenzene	9	0.31 - 2.86	6,9,10, 11
1-Methyl-2-n-propylbenzene	10	0.01 - 0.17	6,9,10
1-Methyl-3-n-propylbenzene	10	0.08 - 0.56	9,10
1-Methyl-3-isopropylbenzene	10	0.01 - 0.12	10
1-Methyl-3-t-butylbenzene	11	0.03 - 0.11	10
1-Methyl-4-t-butylbenzene	11	0.04 - 0.13	10
1,2-Dimethyl-3-ethylbenzene	10	0.02 - 0.19	6,10
1,2-Dimethyl-4-ethylbenzene	10	0.50 - 0.73	6
1,3-Dimethyl-2-ethylbenzene	10	0.21 - 0.59	6,9
1,3-Dimethyl-4-ethylbenzene	10	0.03 - 0.44	6,10
1,3-Dimethyl-5-ethylbenzene	10	0.11 - 0.42	6,10
1,3-Dimethyl-5-t-butylbenzene	12	0.02 - 0.16	10
1,4-Dimethyl-2-ethylbenzene	10	0.05 - 0.36	6,10
1,2,3-Trimethylbenzene	9	0.21 - 0.48	6
1,2,4-Trimethylbenzene	9	0.66 - 3.30	6,9,10, 11
1,3,5-Trimethylbenzene	9	0.13 - 1.15	6,9,10
1,2,3,4-Tetramethylbenzene	10	0.02 - 0.19	6,10
1,2,3,5-Tetramethylbenzene	10	0.14 - 1.06	6,9,10
1,2,4,5-Tetramethylbenzene	10	0.05 - 0.67	6,9,10
Ethylbenzene(d)	8	0.36 - 2.86	6,9,10, 11,12
1,2-Diethylbenzene	10	0.57	9
1,3-Diethylbenzene	10	0.05 - 0.38	6,9,10
n-Propylbenzene	9	0.08 - 0.72	6,9,10
Isopropylbenzene	9	<0.01 - 0.23	6,9,10, 12
n-Butylbenzene	10	0.04 - 0.44	6,9,10
Isobutylbenzene	10	0.01 - 0.08	9,10
sec-Butylbenzene	10	0.01 - 0.13	9,10
t-Butylbenzene	10	0.12	9
n-Pentylbenzene	11	0.01 - 0.14	10
Isopentylbenzene	11	0.07 - 0.17	10

Compound	Number of Carbons	Concentration (Weight Percent) (a)	Reference
Indan	9	0.25 - 0.34	6
1-Methylindan	10	0.04 - 0.17	10
2-Methylindan	10	0.02 - 0.10	10
4-Methylindan	10	0.01 - 0.16	10
5-Methylyindan	10	0.09 - 0.30	10
Tetralin	10	0.01 - 0.14	10
Polynuclear Aromatic Hydrocarbons			
Napthalene(d)	10	0.09 - 0.49	6,10
Pyrene	16	Not quantified	6
Benz(a)anthracene	18	Not quantified	6
Benz(a)pyrene	20	0.19 - 2.8 mg/kg	6
Benzo(e)pyrene	20	Not quantified	6
Benzo(g,h,i)perylene	21	Not quantified	6
Elements			
Bromine		80 - 345 µg/g	3
Cadmium		0.01 - 0.07 µg/g	1
Chlorine		80 - 300 µg/g	3
Lead(b)		530 - 1120 µg/g	8
Sodium		<0.6 - 1.4 µg/g	3
Sulfur(c)		0.10 - 0.15 (ASTM)	
Vanadium		<0.02 - 0.001 µg/g	2,3
Additives			
Ethylene dibromide(d)		0.7 - 177.2 ppm	4
Ethylene dichloride(d)		150 - 300 ppm	8
Tetramethyl lead			
Tetraethyl lead			

a. Conversion from other units assumed 0.75 specific gravity.

b. ASTM specification, maximum, unleaded gasoline, 0.013 g/l maximum, conventional grade gasoline, 1.1 g/l. Title 13, CAC, Section 2253.2, maximum, leaded gasoline other than leaded high octane gasoline, 0.8 g/gallon maximum, leaded high octane gasoline, 1.0 g/gallon. Federal standards, January 1, 1986, maximum, 0.1 g/gallon.

c. ASTM maximum, unleaded gasoline, 0.10 weight percent. Conventional grade gasoline, 0.15 weight percent, Title 13, CAC, Section 2252, maximum 300 ppm by weight.

d. Compounds for which AALs are being developed.

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AIR, WATER & HAZARDOUS WASTE LABORATORY (No.131) CERTIFIED by CALIFORNIA DEPT of HEALTH SERVICES

Central Coast Analytical Services

Central Coast
Analytical Services
141 Suburban Road, Suite C-4
San Luis Obispo, California 93401
(805) 543-2553

Lab Number: S-08248
Collected:
Received:
Tested: 08/24/88
Collected by:

CCAS

Sample Description:

Diesel #2 Standard

SUPPLEMENTARY REPORT FOR EPA 625/8270

CONSTITUENT	APPROXIMATE LEVEL in percent	CONSTITUENT	APPROXIMATE LEVEL in percent
DECANES	0.39	C-4 ALKYLBENZENES	1.8
UNDECANES	1.9	C11H22 HYYDROCARBONS	2.5
DODECANES	2.5	C12H24 HYYDROCARBONS	3.0
TRICANES	2.8	C12H22 HYYDROCARBONS	0.38
TETRADECANES	8.3	DECALIN	0.98
PENTADECANES	9.7	METHYLDECALINS	1.8
HEXADECANES	10.	C-2 ALKYLDECALINS	0.41
HEPTADECANES	8.8	C13H24 HYDROCARBONS	0.45
OCTADECANES	7.0	C13H26 HYDROCARBONS	2.3
NONDECANES	1.9	TETRALIN	1.3
EICOSANES	1.8	C14H28 HYDROCARBONS	1.1
HENEICOSANES	2.6	METHYLNAPHTHALENES	2.7
DOCOSANES	1.7	C13H18 HYDROCARBONS	0.88
TRICOSANES	0.78	C15H28 HYDROCARBONS	1.2
TETRACOSANES	0.52	C-2 ALKYLNAPHTHALENES	3.4
PENTACOSANES	0.39	C-3 ALKYLNAPHTHALENES	1.2
HEXACOSANES	0.39	C15H30 HYDROCARBONS	0.58
HEPTACOSANES	0.26	C16H32 HYDROCARBONS	2.5
C-3 ALKYLBENZENES	0.44	C17H34 HYDROCARBONS	0.62
		POSSIBLE NITROGEN-CONTAINING HETEROCYCLIC	0.62

Respectfully submitted,
CENTRAL COAST ANALYTICAL SERVICES

Mary Havlicek

Mary Havlicek, Ph.D., President

08-25-88
S08248SUP.WR1/#168
MH/bl/mh/rh

IR, WATER & HAZARDOUS WASTE LABORATORY (No.131) CERTIFIED by CALIFORNIA DEPT of HEALTH SERVICES

Central Coast Analytical Services

Central Coast
Analytical Services
141 Suburban Road, Suite C-4
San Luis Obispo, California 93401
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Lab Number: S-08218
Collected:
Received:
Tested: 08/21/88
Collected by:

CCAS

Sample Description:

Percentage Composition of Diesel #4 Standard

SUPPLEMENTARY REPORT FOR EPA 625/8270

CONSTITUENT	APPROXIMATE LEVEL in percent
UNDECANES	0.2
DODECANES	0.2
TRIDECANES	0.9
TETRADECANES	1.7
PENTADECANES	1.8
HEXADECANES	3.6
HEPTADECANES	5.1
OCTADECANES	6.2
NONADECANES	4.8
EICOSANES	6.6
HENEICOSANES	9.7
DOCOSANES	13.
TRICOSANES	13.
TETRACOSANES	13.
PENTACOSANES	8.3
HEXACOSANES	6.8
HEPTACOSANES	2.9
OCTACOSANES	1.1
NONACOSANES	1.0
METHYLNAPHTHALENE	0.3
C17H34 HYDROCARBONS	0.2
METHYLPHENANTHRENES	0.5
C23H40 HYDROCARBONS	1.3
C26H34O POSSIBLE STEROL	0.7

Respectfully submitted,
CENTRAL COAST ANALYTICAL SERVICES

Mary Havlicek

Mary Havlicek, Ph.D., President

09-02-88
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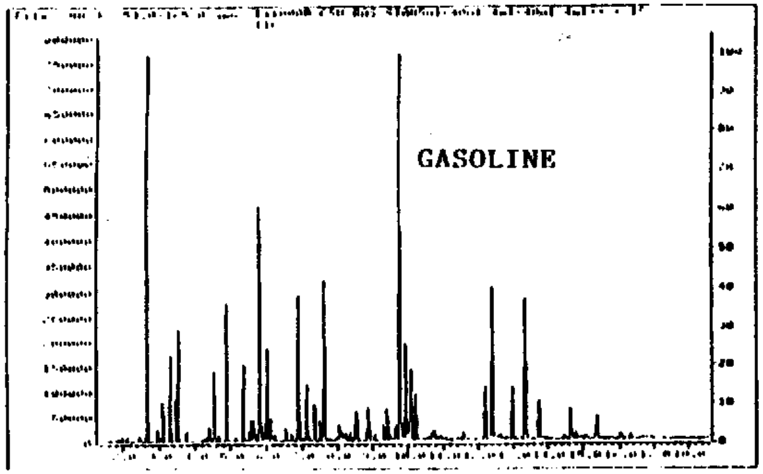

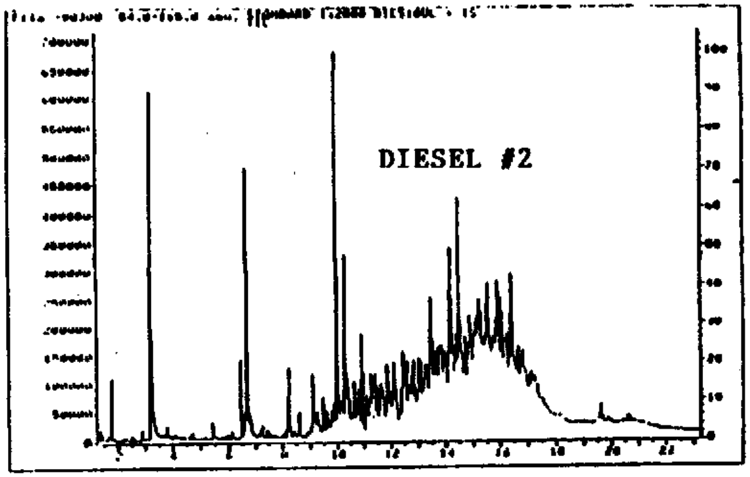

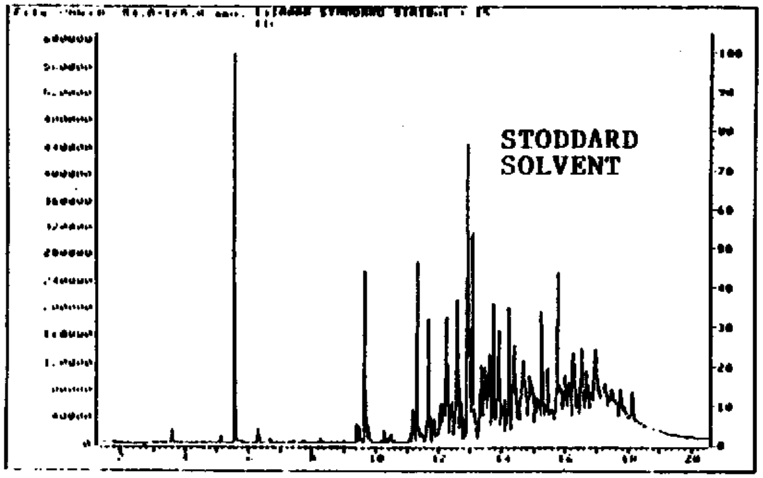

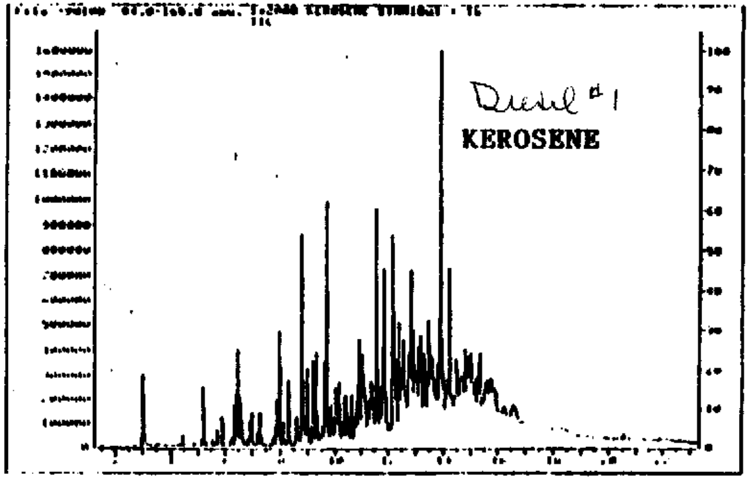

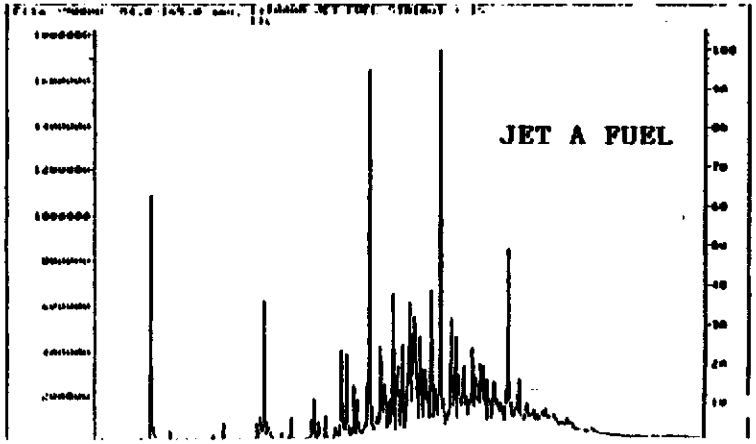

ION CHROMATOGRAMS FOR FUEL STANDARDS BY CCAS USING EPA METHODS 5030 & 8240 (SIM)