Adaptation of the Minerals Management Service's Oil-Weathering Model for Use in the Gulf of Mexico Region

MMS

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Author

Bruce E. Kirstein

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> New Orleans, Louisiana 70123-2394
>
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>
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ABSTRACT

The Minerals Management Service's open-ocean, oil-weathering model has been extensively modified and adapted for use on a personal computer. The modifications include the use of variable wind speed as a function of time as an environmental parameter. The assumptions, governing equations, and algorithms are discussed to illustrate which oil-weathering processes are wind and/or temperature dependent. Wind-speed information and sea-surface temperatures for regions in the Gulf of Mexico are provided so that the modified model can be used immediately. A selection of crude oils and petroleum products produced in and shipped through the Gulf of Mexico region are provided as examples of information required for model use. A discussion of crude oil and petroleum product information sources is also presented. Detailed user's instructions on the use of the model, examples demonstrating the use of the model, and program listings are provided here.

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INTRODUCTION

The <u>M</u>inerals <u>M</u>anagement <u>S</u>ervice's (MMS) open-ocean oil-weathering model (Payne et al. 1984) has been extensively modified and adapted for use on a personal computer. The modifications include the use of variable-wind speed as an independent variable, the conversion of petroleum sub-atmospheric distillation characterization temperatures to one atmosphere and the conversion of Saybolt Seconds viscosity to centipoise. These modifications make the model easier to use and alleviate the user from some of the more cumbersome input-data preparation details. This model can now be used immediately with readily available software and is presented with a library of crudes, refined product inspections, and wind-speed scenarios pertinent to the Gulf of Mexico. All the information required to used this model, create other wind-speed scenarios and obtain other crude oil or refined product inspections is contained in this report. The user can run this model as a prediction tool immediately. To use this model immediately, proceed to the User's Instructions.

The Minerals Management Service's open-ocean oil-weathering model was originally published as a mainframe computer model in 1984 (Payne et al. 1984). The intended use of this model is to predict the material balance of spilled oil remaining on the ocean surface, and to that extent the model does provide a prediction of the mass and composition of the oil remaining in the slick as a function of time. The technical approach used to write the model is the utilization of petroleum-industry crude oil and refined product inspections and physical properties along with known oil-weathering processes. The availability of industry-based inspections is so vast (Aalund 1983, Oil & Gas Journal 1973, U.S. Department of Energy (U.S. DOE) 1987, Bland and Davidson 1967, Gruse and Stevens 1960, Nelson 1969, and Kurtz 1965) that even today the complete utilization of this information for the purpose of oil-weathering predictions has not occurred. Any attempt to derive an oil-weathering model which does not utilize these available data will have to develop an entirely new database, and considering the diversity of crudes (The Lamp 1984), this is impossible. The material-balance algorithms use these available inspections and physical properties along with environmentally determined parameters to predict the rate at which mass leaves the slick. These environmentally determined parameters are the mass transfer coefficient for evaporation and a coefficient for the rate of dispersion of oil from the slick into the water column. The environmental parameters of importance are wind speed and temperature. In the original model presented in 1984 both the wind speed and temperature are fixed.

It is generally known that an increase in the wind speed will result in an increase in the rate at which a substance will evaporate (Liss and Slater 1974). For the situation where oil is evaporating from a flat surface, experimentally derived information predicts an increase in the evaporation rate by a factor of 1.7 for a doubling of the wind speed (Mackay and Matsugu 1973). Also, the

coefficient which determines the rate at which oil is dispersed as droplets into the water column depends on the square of the wind speed (Mackay et al. 1980). Since the weathering of oil in the environment occurs over a period of a few days, a constant wind speed for the duration of the weathering is not realistic. Daily variations in wind speed are normal occurrences, and the passage of weather fronts are associated with changes in wind speed. Thus, in order to predict the material balance of an oil spill, variations in wind speed are justified as model input.

The use of variable wind speeds in the oil-weathering prediction is based on the use of a wind-speed table. The modified model uses a specified wind speed for a specified time (or duration). The wind-speed tables used here are derived from hourly buoy data from the Gulf of Mexico (Brown 1991). Wind data from the Navy's collection of twice-daily one-degree grided wind components for the Gulf of Mexico (Rhodes et al. 1989) were evaluated. However, these twice-daily wind speeds are not recommended for use because these data are too coarse in the time grid. The sea-surface temperatures used, and hence the oil temperature, are obtained from monthly compilations of these temperatures for the Gulf of Mexico (Robinson 1973, Ford et al. 1988). The oil-weathering temperature in the MMS model does not vary because the sea-surface temperatures do not appear to change significantly over the period of a few days.

Crude-oil characterizations pertinent to the Gulf of Mexico are obtained primarily from the U.S. Department of Energy's (DOE) Crude Oil Data Bank (U.S. DOE 1987) in Bartlesville, Oklahoma, and cooperating industrial sources. The DOE Data Bank is extensive and contains over 9,000 crude oil inspections worldwide, both onshore and offshore. Refined petroleum products which are shipped through the Gulf are also discussed here and estimates of their physical properties pertinent for oil-weathering predictions are given.

The software codes developed to implement variable wind speed for oil-weathering predictions are all written in Basic and will run on any personal computer. The only special case is the oil-weathering routine which should be run as a compiled and linked file. Source listings for the oil-weathering codes and utilities to create wind-speed files are presented in the Appendices.

ASSUMPTIONS, GOVERNING EQUATIONS, AND ALGORITHMS

The material balance derived for an oil spill is based on two weathering loss processes: evaporation and dispersion. Evaporation is an oil-species dependent process where the temperature-dependent vapor pressure of the species is the driving force for mass transfer. The dispersion process is the dispersing of oil drops into the water column by mechanical means. Dissolution is not included in the material loss processes because this process is considered to be relatively small. The important physical properties of weathered oil are composition, density and viscosity. Viscosity is of major interest because of its tremendous increase as a water-in-oil emulsion is formed. The water-in-oil emulsion does not always form and recent investigations have identified key components which must be present in the oil for emulsion formation (Bridie et al. 1980). The discussion that follows presents the technical approach used to derive the MMS open-ocean oil-weathering model and how this model is coupled to the environmental wind speed and temperature.

Predicting the quantity of oil in a spill or for any situation involving mass transfer requires that a total material balance approach be used. It is not possible to derive a total material balance for crude oil by using a specific-component approach. If the technical approach is based on specific components it will become apparent that all the compounds in the oil will never be identified (Elliott and Melchior 1982), thus precluding an accounting for the entire mass of oil. Also, it is not possible to choose a single component on which to base bulk properties because single component properties are somewhat erratic (Watson et al. 1935). No predictive equations based on specific components have been developed where the purpose was the prediction of a material balance for a total mass of oil.

The question then is raised as to how to characterize oil so that material balance predictions can be made. The petroleum industry refers to the bulk properties of oil as characterization parameters. The characterization of an oil must be done with respect to a specific prediction objective. For example, when the prediction objective is a process that involves vapor-liquid mass transfer such as evaporation or distillation, the characterization parameters are partial pressures and vapor pressures. Also, when the prediction objective is the performance of a catalytic reformer in a refinery where naphthas are converted to aromatics, the characteristics required on the reformer feedstock are the composition in terms of hydrocarbon types identified as paraffins, olefins, naphthas and aromatics, and this characterization is referred to as a PONA. Kinetic equations in the form of differential equations use the PONA as the starting point and integration yields the final composition at the exit of the process. Both of these examples illustrate a pseudo-component model which is also referred to as a lumped model.

When the prediction objective is the mass of oil remaining in a slick as a function of time as evaporation proceeds, the

characterization must be with respect to vapor pressure. A total material balance utilizes the vapor pressures of the pseudo-components and environmental parameters to predict the loss of oil and, therefore, the mass of oil remaining in the slick. The discussion that follows describes the technical approach used for characterizing crude oils and petroleum products with respect to vapor pressure and how these characterizations are used in the pertinent mass transfer equations.

The petroleum industry standard inspections on a crude oil include a distillation at one atmosphere, the density and viscosity of the distillate fractions. The distillation data come from either an American Society for Test and Materials D-86 distillation (ASTM 1990a) or a true boiling point (TBP) distillation (Smith 1963, ASTM 1990b). Each of these distillations can be conducted at reduced pressure to obtain information on the less volatile fractions of the oil. Each distillation is conducted in such a manner that distilled fractions are collected separately. The total number of fractions, or "cuts" as they are usually denoted, is usually five to seven, but can be as high as 20. Characteristic data for each distilled fraction include the temperatures at the beginning and end of the fraction collection, the API gravity (Hougen et al. 1965) and the viscosity.

Distillations conducted at reduced pressures are frequently published such as those by the U.S. Department of Energy (U.S. DOE 1987). The distillation temperatures reported at reduced pressure must be corrected to one atmosphere total pressure before oil-characterization calculations can proceed. The most common reduced pressure used in distillation characterizations is 40 millimeters of mercury. The procedure to correct these distillation temperatures can be obtained from the open literature in graphical form (API 1970). The correction procedure can be rederived in the form of a quadratic equation for computerized calculations. For the relevant case of correcting 40-mm Hg boiling temperatures to equivalent one atmosphere temperatures the following approximation can be used:

$$BP_{760} = 142.69 + 1.1077\, BP_{40} + 0.0000519\, BP_{40}^2 \qquad (1)$$

where BP_{40} is the boiling point in degrees Fahrenheit ($^\circ$F) at 40-mm Hg and BP_{760} is the boiling point at one atmosphere in $^\circ$F.

Given the average boiling point and API gravity for each cut from the distillation data, the average molecular weight, critical temperature and critical pressure can be obtained. The original technique for using the distillation data to find these dependent variables was to simply look up the required information on a graph (Hougen et al. 1965, Watson et al. 1935). This original information which is in graphical form was fitted to a family of piecewise quadratics for computerized prediction purposes and then used in the MMS open-ocean oil-weathering model (Payne et al. 1984). Note that from the mass and molecular weight the cut concentration in terms of mole fraction can be calculated. The

vapor pressure of the cut can then be calculated in a similar manner (Gamson and Watson 1944).

The mass transfer equation which describes the pseudo-component evaporation of oil is:

$$\frac{dM_i}{dt} = -k_i A x_i P_i^*$$ (2)

where it is assumed that the oil in the slick is well mixed and Raoult's law applies as the mixing rule for partial pressures (Smith and Van Ness 1959), M_i is the number of moles of pseudo-component i in the oil slick, P_i^* is the vapor pressure in atmospheres at the prevailing environment temperature, A is the area for mass transfer and is the area of the slick in square meters, k_i is the mass transfer coefficient based on a partial pressure driving force in units of moles per hour per square meter per atmosphere, and x_i is the mole fraction. The differential equations for all pseudo-components are coupled through the mole fraction term where the total number of moles appears in the denominator of the mole fraction expression.

The over-all mass-transfer coefficient for the i-th pseudo-component is calculated according to (Mackay and Matsugu 1973):

$$k_i = 0.0292 \, U^{0.78} X^{-0.11} Sc_i^{-0.67}$$ (3)

where U is the wind speed in meters per hour, X is the slick diameter in meters (assumes circular shape) and Sc_i is the Schmidt number. The Schmidt number is taken to be 2.7 (unitless) for all pseudo-component species; however note that the Schmidt number is the bulk-phase kinematic viscosity (the air) divided by the pseudo-component diffusivity in air (Bennett and Myers 1962). The Schmidt number dependence on the species and the temperature is not taken into account because these variations are quite small relative to other effects. This expression for k_i is derived from a correlation of data and is the correct mass transfer coefficient to multiply by the partial pressure to obtain the mole rate of evaporation. Implicit in the evaporation rate equation for the i-th pseudo-component is the assumption that its partial pressure in the atmosphere is zero. It can then be seen that the mass transfer coefficient above takes into account through the X term an averaging effect of the partial pressure driving force whereby the evaporation rate on the downwind portion of the slick is lower due to the evaporation from the upwind portion.

The area for mass transfer in the evaporation rate equation is calculated from the rate at which oil spreads on the water surface. Considerable research has been devoted to the spreading of oil on water; however, many of the resulting models are still considered inappropriate. The spreading model used here is due to Mackay (Mackay et al. 1980) and is based on a correlation of observations:

$$\frac{dA}{dt} = K_a Z^{1.33} A^{0.33} \tag{4}$$

where A is the area of the slick in square meters, Z is the slick thickness in meters and K_a is a constant equal to 5.4×10^5.

The viscosity of the oil or petroleum product on a water-free basis is a property which appears in other oil-weathering algorithms and also is a physical property of general interest. The viscosity of weathered oil can be calculated according to (Mackay et al. 1982):

$$\mu_o = \mu_o^* e^{k_\mu F_w} \tag{5}$$

where μ_o is the viscosity of the oil on a water-free basis, μ_o^* is the viscosity of the unweathered oil, k_μ is an oil-dependent constant usually approximately equal to 10.5, and F_w is the fraction of oil weathered. Note that the fraction of oil weathered is based only on the fraction evaporated (and dissolved) and must not include the fraction oil lost from the slick by mechanical means.

The viscosity units reported in the open literature for oil are numerous and include Saybolt Universal Seconds, Redwood No. 1, Saybolt Furol, Redwood No. 2, Engler Degrees and centipoise. The viscosity units used in oil-weathering calculations are centipoise which requires that the other units must be converted. One of the most common units in addition to centipoise is Saybolt Universal Seconds, sometimes denoted as SUS, and these units are sometimes reported by the U.S. Department of Energy (U.S. DOE 1987). In order to utilize the information reported by DOE the conversion of Saybolt Seconds to the kinematic viscosity can be calculated according to (Holman and Gajda 1978):

$$\nu = 92.903 \left[0.00237 \, t - \frac{1.93}{t} \right] \tag{6}$$

where ν is the kinematic viscosity in units of square centimeters per second and t is Saybolt Seconds. In order to obtain absolute viscosity the above must be multiplied by the oil density which can be calculated from the API gravity (Hougen et al. 1965).

The bulk viscosity of the water-free oil can be scaled with respect to temperature according to the Andrada equation (Gold and Ogle 1969):

$$\ln\left[\frac{\mu_1}{\mu_2}\right] = B\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \tag{7}$$

where μ_1 and μ_2 are the viscosities at temperatures T_1 and T_2, and B is an oil-dependent constant approximately equal to 9,000 when the temperature units are degrees Kelvin.

The prediction of the water-in-oil emulsion formation, sometimes referred to as "mousse", is important in oil weathering material balances because of the bulk viscosity increase due to the incorporation of water into the oil. The water-in-oil emulsification algorithm is based on three parameters which appear in the following equation due to Mackay (Mackay et al. 1980):

$$e^{-K_3 t} = (1 - K_2 W)\, e^{\left[\frac{-2.5\,W}{1 - K_1 W}\right]} \tag{8}$$

where W is the weight fraction water in the oil-water mixture, K_1 is a constant in the oil-water viscosity equation due to Mooney (Mooney 1951), K_2 is a coalescing-tendency constant and K_3 is a lumped water-incorporation rate constant. The oil-water viscosity equation due to Mooney is:

$$\mu = \mu_o e^{\left[\frac{-2.5\,W}{1 - K_1}\right]} \tag{9}$$

where μ_o is the parent water-free oil viscosity. K_1 is usually around 0.62 to 0.65 and apparently does not change much with respect to different oils. The constant K_2 must be such that $K_2 W$ is less than unity in order for the water incorporation rate term to be greater than zero. Thus, K_2 is the inverse of the maximum weight fraction water in the emulsion mixture, and is oil and petroleum product dependent as described in the open literature (Bridie et al. 1980). K_3 is the water incorporation rate constant and is a function of the wind speed as indicated:

$$K_3 = 0.036\, W_k^2 \tag{10}$$

where the wind speed W_k is in knots.

The dispersion of oil droplets from the slick into the water column is described by two equations (Mackay et al. 1980) as follows:

$$F = K_d (1 + U)^2 \tag{11}$$

$$F_B = (1 + K_b \mu^{\frac{1}{2}} \delta \chi)^{-1} \tag{12}$$

where F is the fraction of the sea surface subject to dispensions per second, U is the wind speed in meters per second and K_d is a

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constant equal to 0.108. F_b is the fraction of oil droplets below a critical size which does not return to the slick, K_b is a constant equal to 50, μ is the viscosity of the bulk oil-water mixture in centipoise, χ is the slick thickness in meters and δ is the oil-water surface tension in dynes per centimeter. The mass fraction of oil that leaves the slick as dispersed droplets is F_b*F, and this fraction is applied to each pseudo-component. Note that the two mass transfer mechanisms for oil loss from a slick are not the same with respect to how these mechanisms affect each pseudo-component. Evaporation is species dependent; the more volatile components leave the slick quickly relative to the others. However, dispersion in terms of the mass fraction of oil that leaves the slick is applied to each component and is not species dependent.

The material balance for the mass of pseudo-component i in the slick is now calculated according to:

$$\frac{dM_i}{dt} = Evaporation\ loss + Dispersion\ loss \qquad (13)$$

The solution of the set of coupled ordinary differential equations is accomplished with a variable-step fourth-order Runga-Kutta numerical integration algorithm (Greenspan 1971). The stepsize is based on the fastest moving derivative, and for the case where a pseudo-component is so volatile that it will evaporate in less than one hour it is deleted from the equation set.

ENVIRONMENTAL PARAMETERS FOR THE GULF OF MEXICO

The two input environmental parameters required for the MMS open-ocean oil-weathering model are wind speed and temperature. The sources of information available for the wind speed as a function of time are Rhodes (Rhodes et al. 1989), and Brown (Brown 1991). The information presented by Rhodes is referred to as the Navy corrected geostrophic winds for the Gulf of Mexico. These data are in the form of twice-daily one-degree grided wind components (Marshall 1991). The fact that these wind data are on a 12-hour time grid and show large temporal variations for both winter and summer months means that these data are too coarse in time to be used as input for an oil-weathering calculation. Oil-weathering changes occur in time frames much less than 12 hours.

The wind data provided by Brown (Brown 1991) are hourly wind speeds from two buoys in the Gulf of Mexico located at 27.9°N, 95°W (station identification 42019, "LaNelle") and 27°N, 96.5°W (station identification 42020, "Eileen"). These data are acceptable as input for oil-weathering calculations because oil changes which occur in less than one hour are generally not observed. Illustrations of the use of these hourly wind speeds are presented in the User's Instructions.

Sea surface temperatures for the Gulf of Mexico can be obtained from two sources (Robinson 1973, and Ford et al. 1988). A cursory examination of these sources for the locations of stations 42019 and 42020 identified in the preceding paragraph shows that the monthly temperatures generally differ by less than 1°C. The sea surface temperature for these two locations is presented in Table 1 for use with the corresponding wind-speed data from Brown (Brown 1991).

Table 1. Approximate Monthly Sea Surface Temperatures for Buoy
Stations 42019 (27.9°N, 95°W) and 42020 (27°N, 96.5°W) in
the Gulf of Mexico (Robinson 1973)

Month	°C	°F
January	19	66.2
February	17½	63.5
March	20	68.0
April	21	69.8
May	25	77.0
June	27	80.6
July	28	82.4
August	29	84.2
September	28½	83.3
October	27	80.6
November	24½	76.1
December	21	69.8

SELECTION OF CRUDE OILS

The availability of industry-based crude oil inspections is so vast (Aalund 1983, Oil & Gas Journal 1973, U.S. Department of Energy (U.S. DOE) 1987, Bland and Davidson 1967, Gruse and Stevens 1960, Nelson 1969, and Kurtz 1965) that even today the complete utilization of this information for oil-weathering predictions has not occurred. It must be emphasized though that these industry-based inspections only provide physical properties; no information is provided on oil-weathering kinetic constants or other pertinent parameters such as the weight fraction water expected in a water-in-oil emulsion. Information such as this must be derived from real-spill observations or laboratory results.

The selection of crude oils and petroleum products pertinent to the Gulf of Mexico was accomplished using the U.S. Department of Energy Data Bank (U.S. DOE 1987) and industrial sources (Adams 1991, and Rainey 1991). The U.S. DOE Data Bank is a computer-accessible compilation of over 9,000 crude oil assays worldwide, both onshore and offshore. There are two physical properties which are very important with respect to oil-weathering predictions. The first of these is the volume percent gasoline plus naphtha which is an indication of how much of the spill will evaporate rapidly; this fraction has a relatively high vapor pressure and as a result it will evaporate quickly. The other property is the volume percent residuum. Residuum does not evaporate and is the remaining fraction from crude oil after distilling off all the heaviest components. Also, the presence of residuum in greater than a few volume percent is an indicator that the slick will form a water-in-oil emulsion (Bridie et al. 1980).

The initial selection of crude oils for the Gulf of Mexico was made from a retrieval of 61 crudes from the U.S. DOE Data Bank and are presented in Tables 2a and 2b. From these crudes three were selected along with two from industrial sources. These five crudes are presented in Table 3 along with the identification of the disk file that contains the physical property information that is read by the oil-weathering model. The oils from the U.S. DOE are identified as Sugar Creek Field, an example of an extremely light crude with no residuum; Chandeleur Sound Field Block 25, a crude with very little gasoline plus naphtha and 33 volume percent residuum; and Main Pass Block 290, a crude with very little gasoline plus naphtha and 42.7 volume percent residuum. These three crudes represent the extremes of what can be expected in the Gulf Coast region. The inspections for these three crudes are presented in Tables 4a, 4b and 4c respectively.

The inspections received for the High Island Offshore Composite do not include distillation data (Rainey 1991). Therefore a search of the U.S. Department of Energy Data Bank was made for a similar crude based on the available inspections. The matching inspections used are API gravity (36 to 40), volume percent gasoline plus naphtha (25 to 30%) and volume percent kerosine (17 to 21%). The matching crude selected for this composite is presented Table 5.

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   The inspections received for the Gibson Terminal Composite (Adams 1991) are extremely detailed and the pertinent physical properties were extracted and are presented in Table 6.

Table 2a. Retrieval of Louisiana Offshore Crudes from the U.S.
         Department of Energy Data Bank (U.S. DOE 1987) (Physical
         properties tabulated are API gravity, volume percent
         residuum, and weight percent sulfur in crude.)

```
     DATAFILE: CRUDEBANK
11-OCT-91/18:55
     SEARCHKEY  VALUE/RANGE
          LOC   LOUISIANA
          LOC        17.00

     CNTY          900


     SORTED BY CNTY
     RANGE OF VALUES:  900        -   900


NUMBER OF ANALYSES:    61
```

SAMPLE	FIELD	APIG	RESD	SULF
B54091	EUGENE ISLAND, BLK 126	36.2	25.0	0.19
B60025	SHIP SHOAL, BLK 154	29.1	27.7	0.36
B60048	GRAND ISLE, BLK 16	36.4	18.6	0.18
B61021	DELTA,W BLK 30	27.0	32.7	0.33
B61022	DELTA,W BLK 53	32.3	28.2	0.43
B61023	DELTA,W BLK 83	35.0	26.8	0.37
B61109	EUGENE ISLAND, BLK 32	39.4	7.3	0.07
B61110	EUGENE ISLAND, BLK 32	39.2	8.4	0.07
B61111	EUGENE ISLAND, BLK 32	38.2	10.0	0.07
B61112	EUGENE ISLAND, BLK 32	46.9	7.0	0.02
B61113	EUGENE ISLAND, BLK 32	35.8	13.8	0.07
B61114	EUGENE ISLAND, BLK 32	36.8	14.2	0.07
B61115	EUGENE ISLAND, BLK 32	36.0	17.5	0.07
B61116	EUGENE ISLAND, BLK 32	35.2	15.8	0.08
B61129	EUGENE ISLAND, BLK 188	27.1	26.9	0.35
B64044	EUGENE ISLAND, BLK 18	39.2	9.1	0.07
B64045	EUGENE ISLAND, BLK 18	40.9	7.8	0.04
B64047	EUGENE ISLAND, BLK 128	43.6	8.0	0.05
B64048	EUGENE ISLAND, BLK 128	41.5	8.0	0.05
B64062	TIMBALIER,S, BLK 131	35.8	15.3	0.20
B68087	SHIP SHOAL, (BLOCK 176)	38.2	11.6	0.13
B68088	SHIP SHOAL, (BLOCK 176)	36.8	13.3	0.14
B68089	SHIP SHOAL, (BLOCK 176)	37.2	11.7	0.15
B68110	TIMBALIER, SOUTH (BLOCK 176)	37.2	6.5	0.19
B68112	TIMBALIER, SOUTH (BLOCK 135)	29.1	43.0	0.66
B68113	EUGENE ISLAND (BLOCK 238)	37.8	10.1	0.19
B68144	CAMERON, EAST (BLOCK 64)	35.8	20.8	0.13
B68146	MARSH ISLAND, SOUTH (BLOCK 23)	34.6	16.1	0.11

Table 2a. Retrieval of Louisiana Offshore Crudes from the U.S. Department of Energy Data Bank (U.S. DOE 1987) (Physical properties tabulated are API gravity, volume percent residuum, and weight percent sulfur in crude.) (continued)

SAMPLE	FIELD	APIG	RESD	SULF
B68147	SHIP SHOAL (BLOCK 107)	35.8	9.1	0.12
B68158	MARSH ISLAND, SOUTH (BLOCK 73)	33.6	21.0	0.20
B68159	MARSH ISLAND, SOUTH (BLOCK 73)	38.8	14.1	0.15
B68166	EUGENE ISLAND (BLOCK 100)	39.6	11.7	0.08
B68167	CAMERON, WEST (BLOCK 192)	38.4	7.9	0.07
B68168	CAMERON, WEST (BLOCK 192)	37.8	8.2	0.08
B69059	EUGENE ISLAND (BLOCK 276)	35.0	27.6	0.53
B69060	DELTA, WEST (BLOCK 117)	36.4	19.4	0.24
B69061	DELTA, WEST (BLOCK 117)	35.2	22.0	0.27
B70049	MARSH ISLAND,S BLK 6	31.5	24.9	0.13
B70050	TIMBALIER,S BLK 54	34.6	22.2	0.21
B70051	DELTA,W BLK 133	35.4	11.3	0.37
B70052	DELTA,W BLK 105	34.6	24.3	0.37
B70053	PASS,S BLK 62	35.8	27.5	0.27
B70054	DELTA,W BLK 105	31.5	24.2	0.26
B70055	PASS,S BLK 62	35.8	25.0	0.22
B70056	DELTA,W BLK 133	33.8	24.0	0.50
B70057	DELTA,W BLK 133	40.9	10.9	0.26
B70058	GRAND ISLE BLK 41	32.8	27.5	0.24
B70059	DELTA,W BLK 41	34.2	25.3	0.19
B70060	GRAND ISLE BLK 43	32.5	22.2	0.40
B71058	SOUTH PASS (BLOCK 24)	28.6	32.6	0.31
B71059	SOUTH PASS (BLOCK 27)	30.0	26.3	0.29
B71062	DELTA, WEST (BLOCK 30)	25.7	31.3	0.44
B77057	SMI 73	30.8	28.3	0.40
B77067	GRAND ISLE (BLOCK 43)	28.9	30.0	0.34
B77068	DELTA, WEST (BLOCK 58)	41.3	12.6	0.20
B77070	DELTA,W]BLK 152	32.3	20.6	0.37
B77071	MAIN PASS (BLOCK 290)	21.5	42.7	0.31
B77073	MARSH ISLAND, SOUTH (BLOCK 130B)	30.0	30.2	0.64
B77074	MARSH ISLAND, SOUTH (BLOCK 130A)	34.2	23.5	0.57
B79026	DELTA, WEST (BLK. 84)	36.4	22.9	0.34
B79025	CHANDELEUR SOUND (BLK. 25)	26.6	33.2	0.29

Note: When the same field identification and block number appear for some entries, it means that there are different producing depths involved.

Table 2b. Retrieval of Louisiana Offshore Crudes from the U.S.
        Department of Energy Data Bank (U.S. DOE 1987) (Physical
        properties tabulated are weight percent carbon residue of
        residuum, weight percent sulfur in residuum, and volume
        percent gasoline plus naphtha.)

```
        DATAFILE:  CRUDEBANK
11-OCT-91/19:31
        SEARCHKEY   VALUE/RANGE
             LOC    LOUISIANA
             LOC        17.00

        CNTY           900


        SORTED BY CNTY
        RANGE OF VALUES:  900      -   900

     NUMBER OF ANALYSES:    61
```

SAMPLE	FIEL	CRR	SRES	GSNP
B54091	EUGENE ISLAND, BLK 126	2.5		17.6
B60025	SHIP SHOAL, BLK 154	4.7		8.7
B60048	GRAND ISLE, BLK 16	3.9		25.8
B61021	DELTA,W BLK 30	5.7		9.5
B61022	DELTA,W BLK 53	6.7		17.6
B61023	DELTA,W BLK 83	6.7		22.1
B61109	EUGENE ISLAND, BLK 32	1.2		12.6
B61110	EUGENE ISLAND, BLK 32	1.1		13.0
B61111	EUGENE ISLAND, BLK 32	3.7		10.4
B61112	EUGENE ISLAND, BLK 32	1.3		43.0
B61113	EUGENE ISLAND, BLK 32	0.7		6.6
B61114	EUGENE ISLAND, BLK 32	0.7		8.7
B61115	EUGENE ISLAND, BLK 32	0.5		7.7
B61116	EUGENE ISLAND, BLK 32	0.6		5.9
B61129	EUGENE ISLAND, BLK 188	4.6		4.1
B64044	EUGENE ISLAND, BLK 18			14.5
B64045	EUGENE ISLAND, BLK 18	0.5		18.4
B64047	EUGENE ISLAND, BLK 128	1.1		27.7
B64048	EUGENE ISLAND, BLK 128	1.1		23.2
B64062	TIMBALIER,S, BLK 131	4.7		27.4
B68087	SHIP SHOAL, (BLOCK 176)	2.5		15.3
B68088	SHIP SHOAL, (BLOCK 176)	2.6		12.5
B68089	SHIP SHOAL, (BLOCK 176)	2.7		14.0
B68110	TIMBALIER, SOUTH (BLOCK 176)	0.5		13.1
B68112	TIMBALIER, SOUTH (BLOCK 135)	8.3		17.6
B68113	EUGENE ISLAND (BLOCK 238)	2.0		21.7
B68144	CAMERON, EAST (BLOCK 64)	1.3		8.7
B68146	MARSH ISLAND, SOUTH (BLOCK 23)	2.6		13.1
B68147	SHIP SHOAL (BLOCK 107)	4.8		11.1
B68158	MARSH ISLAND, SOUTH (BLOCK 73)	1.3		24.0

Table 2b. Retrieval of Louisiana Offshore Crudes from the U.S. Department of Energy Data Bank (U.S. DOE 1987) (Physical properties tabulated are weight percent carbon residue of residuum, weight percent sulfur in residuum, and volume percent gasoline plus naphtha.) (continued)

SAMPLE	FIEL	CRR	SRES	GSNP
B68159	MARSH ISLAND, SOUTH (BLOCK 73)	3.9		31.9
B68166	EUGENE ISLAND (BLOCK 100)	6.8		23.7
B68167	CAMERON, WEST (BLOCK 192)	1.5		13.8
B68168	CAMERON, WEST (BLOCK 192)	1.5		11.7
B69059	EUGENE ISLAND (BLOCK 276)	6.6		26.1
B69060	DELTA, WEST (BLOCK 117)	6.9		26.9
B69061	DELTA, WEST (BLOCK 117)	6.3		23.6
B70049	MARSH ISLAND,S BLK 6	2.2		13.4
B70050	TIMBALIER,S BLK 54	2.0		18.8
B70051	DELTA,W BLK 133	8.5		22.5
B70052	DELTA,W BLK 105	3.0		19.0
B70053	PASS,S BLK 62	8.6		34.1
B70054	DELTA,W BLK 105	3.8		10.6
B70055	PASS,S BLK 62	9.1		32.1
B70056	DELTA,W BLK 133	10.0		20.8
B70057	DELTA,W BLK 133	7.8		40.1
B70058	GRAND ISLE BLK 41	6.3		17.9
B70059	DELTA,W BLK 41	4.7		20.5
B70060	GRAND ISLE BLK 43	9.7		17.1
B71058	SOUTH PASS (BLOCK 24)	4.9		11.8
B71059	SOUTH PASS (BLOCK 27)	4.9		16.2
B71062	DELTA, WEST (BLOCK 30)	7.4		9.1
B77057	SMI 73	3.3	0.89	14.3
B77067	GRAND ISLE (BLOCK 43)	9.0	0.71	12.8
B77068	DELTA, WEST (BLOCK 58)	4.9	0.80	38.6
B77070	DELTA,W]BLK 152			11.8
B77071	MAIN PASS (BLOCK 290)	12.8	0.52	2.6
B77073	MARSH ISLAND, SOUTH (BLOCK 130B)	6.8	1.30	26.1
B77074	MARSH ISLAND, SOUTH (BLOCK 130A)	6.8	1.40	33.5
B79026	DELTA, WEST (BLK. 84)	6.4	0.84	22.2
B79025	CHANDELEUR SOUND (BLK. 25)	7.7		1.7

Note: When the same field identification and block number appear for some entries it means that there are different producing depths involved.

Table 3. Selection of Gulf of Mexico Crude Oils (The disk file
          identified for each crude is read directly by the
          variable-wind speed oil-weathering model.)

Crude Oil Identification	Disk File
Sugar Creek Field, from BPO[*] Database, extremely light crude, no residuum, BPO No. B39094.	B39094DT.ASC
Chandeleur Sound Field Block 25, from BPO[*] Database, very little gasoline plus naphtha, 33 volume percent residuum, BPO No. B79025.	B79025DT.ASC
Main Pass Block 290, from BPO[*] Database, very little gasoline plus naphtha, 42.7 volume percent residuum, BPO No. B77071.	B77071DT.ASC
Gibson Terminal Composite, currently an item of commerce, 8.7 volume percent gasoline plus naphtha, 31.3 volume percent residuum.	GIBSONT.ASC
High Island Offshore Composite, currently an item of commerce, properties estimated using BPO[*] Database, 27.3 volume percent gasoline plus naphtha, 11.5 volume percent residuum.	HIGHISL.ASC

*BPO is Bartlesville Project Office Crude Oil Analysis Data Bank.
For more detail see the User's Guide for this data bank identified
in the Reference Section as U.S. DOE 1987.

Table 4a. Inspections for Sugar Creek Field Crude from the U.S.
Department of Energy Data Bank (U.S. DOE 1987).

BPO CRUDE OIL DATA BANK
MAINTAINED BY NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH
(NIPER)
BARTLESVILLE, OK
CRUDE OIL ANALYSIS NO. B39094

IDENTIFICATION

SUGAR CREEK FIELD   LOUISIANA
DARRETT, TRAVIS PEAK, COMANCHE, LOWER CRETACEOUS   CLAIBORNE PARISH
5546 FEET

GENERAL CHARACTERISTICS

GRAVITY, SPECIFIC: 0.733   API: 61.5   POUR POINT,DEG F:
SULFUR, WT PCT: 0.10   NITROGEN, WT PCT:
VISCOSITY, SAYBOLT UNIV SEC:
        AT 100 F <   32
             DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1-DISTILLATION AT ATMOSPHERIC PRESSURE

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
1	122	2.6	2.6	0.639	89.9					
2	167	8.3	10.9	0.674	78.4	9				
3	212	19.1	30.0	0.711	67.5	17				
4	257	17.2	47.2	0.726	63.4	15				
5	302	15.4	62.6	0.737	60.5	13				
6	347	13.8	76.4	0.751	56.9	13				
7	392	7.2	83.6	0.764	53.7	13				
8	437	6.4	90.0	0.776	50.8	13				
9	482	3.9	93.9	0.787	48.3	13				
10	527	2.1	96.0	0.797	46.0	13				

STAGE 2-DISTILLATION CONTINUED AT 40 MM HG

11	392									
12	437									
13	482									
14	527									
15	572									
RESIDUUM		3.2	99.2	0.816	41.9					

CARBON RESIDUE, WT PCT: OF RES: SULFUR,   WT PCT OF RES:
  (CONRADSON)   OF CRUDE: NITROGEN, WT PCT OF RES:

Table 4a. Inspections for Sugar Creek Field Crude from the U.S. Department of Energy Data Bank (U.S. DOE 1987) (continued)

APPROXIMATE SUMMARY

	VOL PCT	SP GRAV	API	VISCOSITY
LIGHT GASOLINE	30.0	0.695	72.2	
TOTAL GASOLINE AND NAPHTHA	83.6	0.724	63.9	
KEROSINE DISTILLATE	12.4	0.783	49.2	
GAS OIL	0.0			
NONVISCOUS LUBE DISTILLATE	0.0			50-100
MEDIUM LUBE DISTILLATE	0.0			100-200
VISCOUS LUBE DISTILLATE	0.0			> 200
RESIDUE	3.2	0.816	41.9	
DISTILLATION LOSS	0.8			

BPO CRUDE OIL DATA BANK
MAINTAINED BY NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH (NIPER)
BARTLESVILLE, OK

HYDROCARBON-TYPE ANALYSIS
CRUDE OIL ANALYSIS NO. B39094

***** INSUFFICIENT DATA FOR REPORT *****

END OF ANALYSIS

Table 4b. Inspections for Chandeleur Sound Block 25 Field Crude
from the U.S. Department of Energy Data Bank (U.S. DOE
1987)

BPO CRUDE OIL DATA BANK
MAINTAINED BY NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH
(NIPER)
BARTLESVILLE, OK
CRUDE OIL ANALYSIS NO. B79025

IDENTIFICATION
CHANDELEUR SOUND (BLK. 25) FIELD   LOUISIANA
TEXTULARIA, MIOCENE   OFFSHORE
GENERAL CHARACTERISTICS

GRAVITY, SPECIFIC: 0.895   API: 26.6   POUR POINT,DEG F: <   5
SULFUR, WT PCT: 0.29   NITROGEN, WT PCT: 0.069
VISCOSITY, SAYBOLT UNIV SEC: COLOR: GREENISH-BROWN
          AT 100 F   108
          AT 130 F   66
          DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1-DISTILLATION AT ATMOSPHERIC PRESSURE 746 MM HG
FIRST DROP AT   225 DEGREES F.

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
1	122									
2	167									
3	212									
4	257									
5	302	0.6	0.6	0.804	44.5	-				
6	347	1.1	1.7	0.819	41.3	45	1.44660	129.7		
7	392	2.3	4.0	0.828	39.4	43	1.45231	132.6		
8	437	3.8	7.8	0.835	38.0	41	1.45758	136.2		
9	482	6.9	14.7	0.842	36.6	39	1.46241	138.4		
10	527	10.1	24.8	0.850	35.0	38	1.46797	144.1		

STAGE 2-DISTILLATION CONTINUED AT 40 MM HG

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
11	392	5.6	30.4	0.862	32.7	39	1.47480	150.1	42	< 5
12	437	11.5	41.9	0.868	31.5	38	1.47891	151.3	48	< 5
13	482	10.5	52.4	0.880	29.3	41	1.48572	154.3	66	< 5
14	527	6.8	59.2	0.891	27.3	43			105	12
15	572	7.4	66.6	0.900	25.7	44	.		176	36
RESIDUUM		33.2	99.8	0.943	18.6					

CARBON RESIDUE, WT PCT: OF RES: 7.7   SULFUR,   WT PCT OF RES:
 (CONRADSON)   OF CRUDE: 2.7   NITROGEN, WT PCT OF RES: 0.154

Table 4b. Inspections for Chandeleur Sound Block 25 Field Crude
from the U.S. Department of Energy Data Bank (U.S. DOE
1987) (continued)

APPROXIMATE SUMMARY

	VOL PCT	SP GRAV	API	VISCOSITY
LIGHT GASOLINE	0.0			
TOTAL GASOLINE AND NAPHTHA	1.7	0.814	42.4	
KEROSINE DISTILLATE	0.0			
GAS OIL	35.7	0.850	35.0	
NONVISCOUS LUBE DISTILLATE	17.3	0.869-0.890	.31.3- 27.6	50-100
MEDIUM LUBE DISTILLATE	10.6	0.890-0.903	27.6- 25.2	100-200
VISCOUS LUBE DISTILLATE	1.3	0.903-0.905	25.2- 24.9	> 200
RESIDUE	33.2	0.943	18.6	
DISTILLATION LOSS	0.2			

HYDROCARBON-TYPE ANALYSIS
CRUDE OIL ANALYSIS NO. B79025

FRAC NO.	VOL PCT OF CRUDE	SPEC GRAV	CORR INDEX	AROMATICS VOL PCT OF FRAC	PAR-NAPH VOL PCT OF FRAC	CORR INDEX OF P-N	SPEC GRAV OF P-N
1							
2							
3							
4							
5	0.6	0.804	–	5.2	94.8	43	0.800
6	1.1	0.819	45	6.4	93.6	43	0.815
7	2.3	0.828	43	8.8	91.2	40	0.822
8	3.8	0.835	41	11.9	88.1	35	0.824
9	6.9	0.842	39	12.6	87.4	32	0.828
10	10.1	0.850	38	15.0	85.0	30	0.833
11	5.6	0.862	39	19.6	80.4	29	0.839
12	11.5	0.868	38	20.6	79.4	28	0.845

ANALYSIS OF NAPHTHA FRACTIONS				FRAC	NO. OF RINGS PER MOL:		
FR NO.	VOL PCT OF NAPH	PN PAR	VOL PCT OF NAPH	FR PAR	NO.	TOTAL	AROM	NAPHTHENES

FR NO.	VOL PCT OF NAPH	PN PAR	VOL PCT OF NAPH	FR PAR	FRAC NO.	TOTAL	AROM	NAPHTHENES
2	(INSUFFICIENT DATA)				12	1.7	0.4	1.3
3	(INSUFFICIENT DATA)				14	(INSUFFICIENT DATA)		
4								
5	100.0	0.0	94.8	0.0				
6	100.0	0.0	93.6	0.0				
7	100.0	0.0	91.2	0.0				

Table 4b. Inspections for Chandeleur Sound Block 25 Field Crude
from the U.S. Department of Energy Data Bank (U.S. DOE
1987) (continued)

SUMMARY DATA FOR BLENDS

	NAPHTHA BLEND (FR5-7)	GAS OIL BLEND (FR 8-12)
VOLUME PERCENT OF CRUDE IN BLEND	4.0	37.9
AROMATIC, VOL PCT OF BLEND	7.6	16.6
PARAFFIN-NAPHTHENE, VOL PCT OF BLEND	92.4	83.4
NAPHTHENE, VOL PCT OF BLEND	92.4	
PARAFFIN, VOL PCT OF BLEND	0.0	
NAPHTHENE, VOL PCT OF P-N IN BLEND	100.0	
PARAFFIN, VOL PCT OF P-N IN BLEND	0.0	
NAPHTHENE RING, WT PCT OF P-N IN BLEND	70.3	45.3
PAR + SIDE CHAINS, WT PCT OF P-N IN BLEND	29.7	54.7

Table 4c. Inspections for Main Pass Block 290 Field Crude from the U.S. Department of Energy Data Base (U.S. DOE 1987)

BPO CRUDE OIL DATA BANK
MAINTAINED BY NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH (NIPER)
BARTLESVILLE, OK
CRUDE OIL ANALYSIS NO. B77071

IDENTIFICATION

MAIN PASS (BLOCK 290) FIELD   LOUISIANA
K2RA, MIOCENE   OFFSHORE
GENERAL CHARACTERISTICS

GRAVITY, SPECIFIC: 0.925   API: 21.5   POUR POINT,DEG F: <   5
SULFUR, WT PCT: 0.31   NITROGEN, WT PCT: 0.134
VISCOSITY, SAYBOLT UNIV SEC: COLOR: BROWNISH-BLACK
          AT 100 F   336
          AT 130 F   160
          DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1-DISTILLATION AT ATMOSPHERIC PRESSURE 742 MM HG
FIRST DROP AT   169 DEGREES F.

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
1	122									
2	167									
3	212									
4	257	0.6	0.6	0.769	52.5	–				
5	302	0.8	1.4	0.777	50.6	32	1.42593	128.8		
6	347	1.2	2.6	0.805	44.3	38	1.43925	130.7		
7	392	2.0	4.6	0.826	39.8	42	1.45023	132.3		
8	437	3.0	7.6	0.842	36.6	44	1.45951	135.6		
9	482	5.7	13.3	0.853	34.4	44	1.46700	138.3		
10	527	5.1	18.4	0.861	32.8	43	1.47291	143.8		

STAGE 2-DISTILLATION CONTINUED AT 40 MM HG

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
11	392	5.1	23.5	0.875	30.2	45	1.48106	149.7	45	< 5
12	437	8.1	31.6	0.882	28.9	45	1.48585	153.6	53	< 5
13	482	8.7	40.3	0.895	26.6	48			74	< 5
14	527	8.4	48.7	0.907	24.5	50			137	< 5
15	572	8.0	56.7	0.916	23.0	52			340	< 5
RESIDUUM	42.7		99.4	0.976	13.5					

CARBON RESIDUE, WT PCT: OF RES: 12.8   SULFUR,   WT PCT OF RES: 0.52
  (CONRADSON)   OF CRUDE: 5.8   NITROGEN, WT PCT OF RES: 0.309

Table 4c. Inspections for Main Pass Block 290 Field Crude from the
U.S. Department of Energy Data Base (U.S. DOE 1987)
(continued)

APPROXIMATE SUMMARY

	VOL PCT	SP GRAV	API	VISCOSITY
LIGHT GASOLINE	0.0			
TOTAL GASOLINE AND NAPHTHA	2.6	0.788	48.1	
KEROSINE DISTILLATE	0.0			
GAS OIL	⌐22.5	0.857	33.7	
NONVISCOUS LUBE DISTILLATE	14.3	0.879-0.900	29.4- 25.7	50-100
MEDIUM LUBE DISTILLATE	7.6	0.900-0.910	25.7- 24.0	100-200
VISCOUS LUBE DISTILLATE	9.7	0.910-0.920	24.0- 22.2	> 200
RESIDUE	42.7	0.976	13.5	
DISTILLATION LOSS	0.6			

HYDROCARBON-TYPE ANALYSIS
CRUDE OIL ANALYSIS NO. B77071

FRAC NO.	VOL PCT OF CRUDE	SPEC GRAV	CORR INDEX	AROMATICS VOL PCT OF FRAC	PAR-NAPH VOL PCT OF FRAC	CORR INDEX OF P-N	SPEC GRAV OF P-N
1							
2							
3							
4	0.6	0.769	—				
5	0.8	0.777	32	5.1	94.9	29	0.772
6	1.2	0.805	38	7.2	92.8	35	0.799
7	2.0	0.826	42	8.6	91.4	39	0.820
8	3.0	0.842	44	11.4	88.6	39	0.833
9	5.7	0.853	44	12.6	87.4	38	0.841
10	5.1	0.861	43	15.0	85.0	36	0.846
11	5.1	0.875	45	19.7	80.3	· 36	0.855
12	8.1	0.882	45	22.7	77.3	35	0.860

ANALYSIS OF NAPHTHA FRACTIONS

FR NO.	VOL PCT OF NAPH	PN PAR	VOL PCT OF NAPH	FR PAR
2	(INSUFFICIENT DATA)			
3	(INSUFFICIENT DATA)			
4				
5	80.4	19.6	76.3	18.6
6	100.0	0.0	92.8	0.0
7	100.0	0.0	91.4	0.0

FRAC NO.	NO. OF RINGS PER MOL: TOTAL	AROM	NAPHTHENES
12	1.9	0.4	1.5
14	(INSUFFICIENT DATA)		

Table 4c. Inspections for Main Pass Block 290 Field Crude from the
U.S. Department of Energy Data Base (U.S. DOE 1987)
(continued)

SUMMARY DATA FOR BLENDS

	NAPHTHA BLEND (FR4-7)	GAS OIL BLEND (FR 8-12)
VOLUME PERCENT OF CRUDE IN BLEND	4.0	27.0
AROMATIC, VOL PCT OF BLEND	7.5	17.3
PARAFFIN-NAPHTHENE, VOL PCT OF BLEND	92.5	82.7
NAPHTHENE, VOL PCT OF BLEND	88.9	
PARAFFIN, VOL PCT OF BLEND	3.6	
NAPHTHENE, VOL PCT OF P-N IN BLEND	96.1	
PARAFFIN, VOL PCT OF P-N IN BLEND	3.9	
NAPHTHENE RING, WT PCT OF P-N IN BLEND	60.4	55.2
PAR + SIDE CHAINS, WT PCT OF P-N IN BLEND	39.6	44.8

Table 5. Crude Analysis for Approximation of High Island Offshore
Composite from the U.S. Department of Energy Data Bank
(U.S. DOE 1987)

BPO CRUDE OIL DATA BANK
MAINTAINED BY NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH (NIPER)
BARTLESVILLE, OK
CRUDE OIL ANALYSIS NO. B63134

IDENTIFICATION

BIG HILL,NW FIELD   TEXAS
FRIO, 8900 FT, OLIGOCENE   JEFFERSON COUNTY
8970 FEET

GENERAL CHARACTERISTICS

GRAVITY, SPECIFIC: 0.835   API: 38.0   POUR POINT,DEG F: <   5
SULFUR, WT PCT: 0.13   NITROGEN, WT PCT: 0.018
VISCOSITY, SAYBOLT UNIV SEC:
         AT 100 F   35
              DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1-DISTILLATION AT ATMOSPHERIC PRESSURE

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
1	122	0.6	0.6	0.654	84.9					
2	167	1.9	2.5	0.675	78.1	10	1.37894	124.2		
3	212	3.1	5.6	0.719	65.3	21	1.40094	131.7		
4	257	5.5	11.1	0.744	58.7	24	1.41470	136.4		
5	302	5.3	16.4	0.765	53.5	26	1.42659	142.8		
6	347	6.9	23.3	0.781	49.7	27	1.43497	142.6		
7	392	4.0	27.3	0.795	46.5	27	1.44087	137.9		
8	437	8.5	35.8	0.809	43.4	28	1.44742	137.3		
9	482	9.9	45.7	0.825	40.0	31	1.45530	139.0		
10	527	11.0	56.7	0.842	36.6	34	1.46377	142.4		

STAGE 2-DISTILLATION CONTINUED AT 40 MM HG

FRAC NO.	CUT TEMP F	VOL PCT	SUM VOL PCT	GRAVITY SPEC (60/60 F)	API	CORR INDEX	REFRACT INDEX,ND (20 C)	SPEC DISP	SU VISC SECS (100 F)	CLOUD POINT F
11	392	10.1	66.8	0.861	32.8	39	1.47371	145.6	43	5
12	437	6.9	73.7	0.873	30.6	41	1.47829	146.4	53	25
13	482	5.9	79.6	0.882	28.9	42	1.48527	148.3	76	45
14	527	4.2	83.8	0.895	26.6	45	1.49201	-	150	60
15	572	3.6	87.4	0.908	24.3	48			195	70
RESIDUUM		11.5	98.9	0.941	18.9					

CARBON RESIDUE, WT PCT: OF RES: 2.3   SULFUR,   WT PCT OF RES:
   (CONRADSON)   OF CRUDE: 0.3   NITROGEN, WT PCT OF RES:

Table 5. Crude Analysis for Approximation of High Island Offshore
Composite from the U.S. Department of Energy Data Bank
(U.S. DOE 1987) (continued)

APPROXIMATE SUMMARY

	VOL PCT	SP GRAV	API	VISCOSITY
LIGHT GASOLINE	5.6	0.697	71.5	
TOTAL GASOLINE AND NAPHTHA	27.3	0.755	55.8	
KEROSINE DISTILLATE	18.4	0.818	41.6	
GAS OIL	22.0	0.852	34.6	
NONVISCOUS LUBE DISTILLATE	10.6	0.869-0.886	31.3- 28.2	50-100
MEDIUM LUBE DISTILLATE	7.7	0.886-0.909	28.2- 24.1	100-200
VISCOUS LUBE DISTILLATE	1.4	0.909-0.914	24.1- 23.3	> 200
RESIDUE	11.5	0.941	18,9	
DISTILLATION LOSS	1.1			

HYDROCARBON-TYPE ANALYSIS
CRUDE OIL ANALYSIS NO. B63134

FRAC NO.	VOL PCT OF CRUDE	SPEC GRAV	CORR INDEX	AROMATICS VOL PCT OF FRAC	PAR-NAPH VOL PCT OF FRAC	CORR INDEX OF P-N	SPEC GRAV OF P-N
1	0.6	0.654	–	0.0	100.0	–	0.654
2	1.9	0.675	10	1.1	98.9	9	0.673
3	3.1	0.719	21	6.4	93.6	16	0.708
4	5.5	0.744	24	10.0	90.0	17	0.730
5	5.3	0.765	26	16.2	83.8	16	0.744
6	6.9	0.781	27	16.8	83.2	17	0.761
7	4.0	0.795	27	13.0	87.0	20	0.780
8	8.5	0.809	28	12.3	87.7	21	0.794
9	9.9	0.825	31	12.8	87.2	23	0.809
10	11.0	0.842	34	13.6	86.4	26	0.826
11	10.1	0.861	39	16.4	83.6	30	0.842
12	6.9	0.873	41	17.2	82.8	33	0.856

ANALYSIS OF NAPHTHA FRACTIONS

FR NO.	VOL PCT OF PN NAPH	PAR	VOL PCT OF FR NAPH	PAR	FRAC NO.	NO. OF TOTAL	RINGS AROM	PER MOL: NAPHTHENES
2	13.0	87.0	12.9	86.0	12	1.9	0.2	1.7
3	30.9	69.1	28.9	64.7	14	2.3	0.5	1.8
4	41.7	58.3	37.5	52.5				
5	42.4	57.6	35.5	48.3				
6	43.7	56.3	36.4	46.8				
7	59.6	40.4	51.9	35.1				

Table 5. Crude Analysis for Approximation of High Island Offshore
          Composite from the U.S. Department of Energy Data Bank
          (U.S. DOE 1987) (continued)

SUMMARY DATA FOR BLENDS

	NAPHTHA BLEND (FR1-7)	GAS OIL BLEND (FR 8-12)
VOLUME PERCENT OF CRUDE IN BLEND	27.3	46.4
AROMATIC, VOL PCT OF BLEND	12.1	14.3
PARAFFIN-NAPHTHENE, VOL PCT OF BLEND	87.9	85.7
NAPHTHENE, VOL PCT OF BLEND	35.9	
PARAFFIN, VOL PCT OF BLEND	52.0	
NAPHTHENE, VOL PCT OF P-N IN BLEND	40.8	
PARAFFIN, VOL PCT OF P-N IN BLEND	59.2	
NAPHTHENE RING, WT PCT OF P-N IN BLEND	23.4	39.6
PAR + SIDE CHAINS, WT PCT OF P-N IN BLEND	76.6	60.4

Table 6. Inspections for Gibson Terminal Composite, Information Extracted from Industry Inspections (Adams 1991).

Distillation Data (see Note below)			
Cut Range, $^{\circ}$F	Cut Degrees F	Volume %	API Gravity
113-155	134	1.5	76.2
155-265	210	8.9	58.5
265-351	308	8.7	50.1
351-401	376	5.5	45.2
401-500	450	16.1	38.5
500-600	550	11.1	32.4
600-650	625	6.7	29.2
650-750	700	7.1	27.1
750+	850	31.3	20.0

Bulk API Gravity = 34.5
Pour Pt, Degree F = -40.0

Vis SSU 40°F = 85.1
Vis SSU 60°F = 58.7
Vis SSU 80°F = 49.0

Gasoline plus Naphtha, volume % = 21
Kerosine fraction, volume % = 22

Conradson Carbon in 1000+, weight % = 7.6

Note: The distillation volume percent yield data will not sum to 100%; the IBP-113 fraction is deleted. For oil-weathering prediction purposes this fraction will be deleted by the code because it is too volatile to exist for any significant time in the environment. The oil-weathering code will renormalize the data as required.

SELECTION OF PETROLEUM PRODUCTS

There are a variety of petroleum products that are shipped through the Gulf of Mexico. These products include gasoline, aircraft gas-turbine fuels, diesel fuels, fuel oils and miscellaneous light oils such as kerosine and industrial naphthas. The following paragraphs present a discussion of these six products and their physical properties pertinent for oil-weathering predictions. These petroleum products were selected for the oil-weathering physical property files because these products represent the entire range of vapor pressure that can be expected.

Gasoline is the product which refiners make and sell in the largest volume. Gasoline is defined as a petroleum fuel designed for use in reciprocating, spark-ignition, internal-combustion engines. The American Society of Testing and Materials (ASTM 1990c) does not provide a specification which can be used as the basis for physical properties of this product because the specification is in terms of maximums and minimums. The average distillation of gasoline will vary somewhat with the season, but such details are not considered pertinent for oil-weathering predictions. A set of inspections which can be used as input for oil-weathering predictions for a gasoline cut from a Louisiana Delta crude is:

Table 7. Estimate of Inspections for Gasoline		
Cut Degrees F	API Gravity	Volume %
130	70	20
180	64	20
220	62	20
260	60	20
295	58	20

The cut temperatures tabulated here are not exactly in the same range as those specified in the ASTM specification; the ASTM distillation specification is not a true boiling point (TBP) distillation, rather it utilizes only a few plates and is referred to as a D-86 distillation. The bulk API gravity for the above gasoline cut is estimated at 62.8 and the viscosity at 70°F is 0.5 centipoise.

Jet fuels, which are aircraft gas-turbine fuels, include the commonly known JP-4 which is a gasoline-kerosene mixture with a vapor pressure of 2 to 3 pounds per square inch, and a boiling range of 200°F to 500°F. The ASTM specification for aviation turbine fuels (ASTM 1990d), as in the gasoline specification, specifies maximum boiling points (no minimums); the maximum boiling temperature at 90% recovered is 473°F. Also, the jet fuels in this

specification are referred to as Jet A or Jet A-1, and Jet B. A set of inspections which can be used as input for oil-weathering predictions for jet fuel boiling between 200°F and 500°F is:

Table 8. Estimate of Inspections for Jet Fuel		
Cut Degrees F	API Gravity	Volume %
260	51.0	20
340	49.5	20
395	46.0	20
420	42.0	20
495	39.0	20

The bulk API gravity for the above jet fuel is estimated at 45.5 and the viscosity is 2.2 centipoise at -30°F.

Diesel fuels, or diesel fuel oils, are produced in many grades: Grade 1-D which comprises the class of volatile fuel oils from kerosine to the intermediate distillates are used in high-speed engines operating at frequent and relatively wide variations in loads and speeds and for applications where fuel temperatures are abnormally low. Grade 2-D includes distillate gas oils of lower volatility used in high-speed engines at relatively high loads and uniform speeds or in engines not requiring the higher volatility of the previous grade. Grade 4-D covers the more viscous distillates and blends of these distillates with residual fuel oils. This grade is used in engines operating at low and medium speeds with sustained loads. ASTM specification (ASTM 1990e) again specifies minimum and maximum inspection parameters. It is noted that there is also a grade DF-A which is referred to as an arctic diesel. Diesel fuels generally boil in the range between 350 and 700°F with a viscosity in the range of 1.4 to 6.0 centistokes (except for grade DF-4 which can range up to 20.6 centistokes) and a gravity of whatever is recorded. Note that the gravity is not entirely arbitrary because of the specification of the kinematic viscosity which is the absolute viscosity divided by the density.

A set of inspections which can be used as input for oil-weathering predictions for a diesel cut from a South Texas (sweet) crude is:

Table 9. Estimate of Inspections for Diesel Fuel		
Cut Degrees F	API Gravity	Volume %
395	46.0	18
440	41.0	18
495	38.0	18
550	35.0	18
630	30.0	28

The bulk API gravity for the above diesel fuel is estimated at 37.2 and the viscosity at 35 Saybolt Seconds at 100°F.

Distillate fuel oils are those distilled oils referred to as distillates and residuals. There are eight grades: Grade No. 1 is a light distillate intended for use in burners of the vaporizing type where high volatility is required. Grade No. 2 is a heavier distillate and is intended for use in atomizing type burners which spray oil into a combustion chamber. This type of oil is used in most domestic burners (i.e., home heating oil) and in many medium capacity commercial-industrial burners where its ease of handling justifies its higher cost over residual fuels. Grade No. 4 (Light) is a heavy distillate fuel oil or distillate/residual fuel blend meeting a specified viscosity range. Its permissible viscosity range allows it to be pumped and atomized at relatively low-storage temperatures. Grade No. 4 is usually a heavy distillate/residual fuel blend but can be a heavy distillate fuel meeting a specified viscosity range. It is intended for use in burners equipped with devices that atomize oils of higher viscosities than domestic burners can handle. Grade No. 5 (Light) is a residual fuel of intermediate viscosity for burners capable of handling fuel more viscous than the previous grade. Grade No. 5 (Heavy) is a residual fuel more viscous than the corresponding light. Grade No. 6, sometimes referred to as Bunker C, is a high-viscosity oil used mostly in commercial and industrial heating. It requires preheating in the storage tank to permit pumping. There is also a Residual Fuel supplied to meet regulations requiring low sulfur content and may differ for the previous grade. The ASTM specification (ASTM 1990f) again specifies minimum and maximum distillation temperatures. For example the maximum distillation temperature at which 10 volume percent is recovered is specified at 419°F for Grade No. 1.

Clearly there is a wide range of distillate fuel oils supplied and all of these will not weather in the same manner in the environment. However, for the purpose of specifying the physical properties of fuel oil, a "wide range" gas oil which generally boils between 430°F and 850°F is used:

Table 10. Estimate of Inspections for a Wide Range Fuel Oil		
Cut Degrees F	API Gravity	Volume %
460	39.4	21.1
520	37.0	21.0
575	35.0	19.3
650	31.0	19.3
750	25.0	19.3

The bulk API gravity for the above wide range fuel oil is estimated at 33.6 and the viscosity is 40 Saybolt Seconds at 100°F.

Kerosine is the general name applied to the group of refined petroleum fractions employed as fuel for lamps and for heating appliances requiring a uniform, nonviscous fuel less volatile than gasoline. It is ordinarily a material boiling over the range 350°F to 525°F with a specific gravity of approximately 0.80. Its viscosity is typically about 2.5 centistokes. The ASTM specification (ASTM 1990g) includes two grades: No. 1-K which is a special low-sulfur grade suitable for use in nonflue-connected kerosine burner applications. No. 2-K is a regular grade kerosine suitable for use in flue-connected burner applications. The distillation specifications for kerosine are a maximum of 10 volume percent recovered at 401°F and a maximum final boiling point of 572°F. A set of specifications which can be used as input for oil-weathering predictions for kerosine is:

Table 11. Estimate of Inspections for Kerosine		
Cut Degrees F	API Gravity	Volume %
410	44.5	20
430	42.0	20
460	40.0	20
480	38.0	20
500	36.5	20

The bulk API gravity for the above kerosine is estimated at 40.2 and the viscosity is 2.5 centipoise at 100°F.

The industrial naphthas include such products as petroleum ether, rubber solvent, light spirits, high-flash VM&P naphthas, light mineral spirits, Stoddard solvent and odorless mineral spirits. These naphthas vary in composition from paraffin-type hydrocarbons to aromatics, and in some cases may contain naphthenes

(naphthenes are derivatives of ring compounds such as cyclopentane and cyclohexane) and olefins. All of these products will not be discussed, but the naphtha that is generally heard of from time to time is VM&P naphtha (from varnish makers' and painters' naphtha), and its specifications will be estimated. ASTM specification (ASTM 1990h) provides the standard specification for VM&P naphthas. There are three types: Type I is called regular naphtha and has a distillation with an initial minimum boiling point of 235°F and a dry point of 310°F. Type II is called a high-flash naphtha with an initial minimum boiling point of 280°F and a dry point of 350°F. Type III is called odorless naphtha and is similar in its distillation to Type I. The ASTM specification does not give a viscosity specification. A set of specifications which can be used as input for oil-weathering predictions for VM&P naphtha is:

Table 12. Estimate of Inspections for VM&P Naphtha		
Cut Degrees F	API Gravity	Volume %
240	55.0	25
280	53.0	25
420	51.0	25
340	48.4	25

The bulk API gravity for the above VM&P naphtha is estimated at 51.8 and the viscosity is estimated to be 0.5 centipoise at 122°F.

A summary of the petroleum products discussed here is presented in Table 13 where the boiling range is tabulated along with the identification of the disk file which contains the physical property information that is read by the oil-weathering model. These product inspections were estimated from a wide variety of data from many sources. True Boiling Point distillations and API gravities on each distillation cut are the required input for oil-weathering predictions, but these inspections are not all that common. The most accessible source of distillation data are those published from time to time in the Oil & Gas Journal since 1973. (Aalund 1983, and Oil & Gas Journal 1973).

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Table 13. Summary of Selected Petroleum Products Shipped through the Gulf of Mexico (The disk file identified for each product is read directly by the oil-weathering model.)

Petroleum Product Identification	Boiling Range Degrees F	Disk File
Gasoline	130 - 295	GASOLINE.ASC
VM&P Naphtha	240 - 340	VM&PNAPH.ASC
Jet Fuel	260 - 495	JETFUEL.ASC
Kerosine	410 - 500	KEROSINE.ASC
Diesel Fuel	395 - 630	DIESEL.ASC
Wide Range Fuel Oil	460 - 750	WRFULOIL.ASC

CODE AND FILE INSTALLATION

The variable-wind speed oil-weathering model is written as a series of Basic codes stored in ASCII format. The input data files required to run these codes immediately are also stored in ASCII format. All these codes and data files are stored on the write-protected disk labelled MMSVW dated February 25, 1992. The instructions that follow for installation are specific to MS-DOS® systems and IBM® compatible personal computers. To install these files make a directory on the hard disk and copy all the files from disk MMSVW to this new directory. The sequence of commands may appear as follows:

```
MD VARW (enter)
CD VARW (enter)
COPY A:*.* C: (enter)
```

These three commands make the directory VARW, change to VARW as the default directory and then copy all the files from the A drive to the default directory.

At this point it is necessary to compile and link the oil-weathering routine OILWIND.BAS. This routine is the numerical integration routine and running this particular routine in interpreted mode can be quite slow. The specific instructions for your installation's compiler must be followed. In general most of the available Basic compilers are similar, and a sequence of commands may appear as follows:

```
BASCOM OILWIND /O; (enter, that is an "oh")
```

When this command string is finished the DOS prompt will be displayed. At this point the object file OILWIND.OBJ will exist in the default directory. Next, this object file must be linked using your installation's LINK routine which is compatible with the DOS version being used. To link the OILWIND.OBJ the sequence of commands may appear as follows:

```
LINK OILWIND (enter)
(enter)
(enter)
BASCOM.LIB (enter)
```

The two intermediate enters above are default entries. When this sequence of commands is finished an executable file OILWIND.EXE will be in the default directory. The object file OILWIND.OBJ can now be deleted.

This finishes the installation procedure. The default directory will contain the codes listed in Table 14, the crude-oil characterization files listed in Table 3 on page 17, the petroleum-product characterization files listed in Table 13 on page 36, and a wind-speed file identified as GM19DE21.A90.

Table 14.   List of Codes Required to Run the MMS Open-Ocean
            Variable Wind-Speed Oil-Weathering Model

Code Name	Purpose of Code
CUTVPW.BAS	Oil-characterization and weathering-specification routine, prepares an oil-weathering input file.
OILWIND.BAS	Oil-weathering code, should be run as a compiled and linked .EXE file.
PRTCHAR.BAS	Prints hard copy of the oil-characterization and weathering specifications.
PRTRSLT.BAS	Prints hard copy of the oil-weathering predictions.
WSPEED.BAS	Allows user to create or edit wind-speed (and duration) tables in the form of a disk file which can be read by CUTVPW.BAS.
WSPRINT.BAS	Prints hard copy of the wind speed (and duration) tables.
WSPACK.BAS	Allows user to concatenate two wind speed files.
*F.BAS	By adding an "F" to the name of any of the three above print routines a DOS-text disk file can be created instead of hard copy. The DOS-text file can then be imported into a word processor.

USER'S INSTRUCTIONS: RUNNING THE CODE WITH LIBRARY FILES

The oil-weathering model can be used immediately after installation as described in the previous section. The user must know which crude oil characterization or petroleum product characterization file is to be used, and also which wind-speed file is to be used. The user can create both of these input files, or use the library files listed in Table 3 (page 17) for the crude oil characterization files, or those listed in Table 13 (page 36) for the petroleum product characterization files, and those listed in Table 15 on the following pages for a wind-speed file. This particular wind-speed file contains 264 hourly wind-speed entries beginning at 0100 hours on December 21, 1990, from the Gulf of Mexico buoy identified as station 42019 ("LaNelle").

To run the oil-weathering codes, first load your installation's version of Basic, and then load CUTVPW.BAS. In general most of the available versions of Basic are similar and a sequence of commands may appear as follows:

```
GWBASIC (enter)
KEY OFF (enter, to turn off the F key template)
LOAD"CUTVPW (enter, and wait for the "ok")
```

When this sequence of commands is finished the oil-characterization and oil-weathering specification routine is ready to run. To run this code in interpreted Basic, enter RUN (with no period). Now the user need only respond to the program prompts. To illustrate, enter R to read an oil-characterization file and at the file prompt enter GIBSONT.ASC (which is the Gibson Terminal Composite characterization file name in Table 3). Then enter NO for the next four(4) prompts to accept the default characterization parameters. At the temperature prompt for the vapor pressure calculation enter 70. This is the surface temperature of the Gulf of Mexico for the buoy identified in Table 15 for the month of December.

After a brief pause the oil-weathering specification prompts begin; for this illustration enter a spill size in barrels of 1000, and for the number of hours for weathering to occur enter 96.

Next the code will prompt for the wind-speed file name, enter GM19DE21.A90 exactly as shown here. For the next two prompts regarding slick spreading and dispersion enter YES both times. Then enter NO when prompted to change any of the seven(7) oil-weathering specification parameters unless an input error has occurred.

The code will then tell you that you should have a hard copy of the wind-speed file specified above; for this example the file GM19DE21.A90 is printed in Table 15 on the following pages. The prompt for the starting wind-speed entry can be any entry in Table 15. This starting entry is the first entry that the oil-weathering code will use to set the wind speed for the duration indicated; for this illustration enter 30. Then the code will prompt for the ending wind-speed entry to use; referring to Table 15, enter 50. Thus, only 20 hours of this wind-speed file will be

used.   The final prompt for wind-speed entry information will be
for a loop-back entry to be used; here enter 30 and then YES if
everything went correctly. The oil-weathering code will loop back
in the wind-speed table to entry 30 when 20 hours of weathering
have occurred. This loop-back entry prevents the code from running
out of wind speeds and allows the user to use any number of wind-
speed scenarios from a single wind-speed file.   In this
illustration the oil-weathering calculation will weather through
the "norther" which occurs at entry number 40.

The final prompt will be for a file name for storing the oil-
characterization and oil-weathering specifications for this
particular case; enter GIBTCHR.ASC (with no period). This finishes
the input for CUTVPW.BAS and now the oil-weathering code can be
run. To exit Basic enter SYSTEM.

At the DOS echo the compiled and linked oil-weathering code
named OILWIND can be run by entering OILWIND (with no period).
This code reads an intermediate data file created by CUTVPW and
writes to an intermediate output file.   The user can see the
progress of the calculation by watching the monitor. When the
calculation is complete a completion message will appear on the
monitor.   This finishes the running of the variable-speed oil-
weathering code and the results can now be printed.

To print the oil-weathering results load Basic again and load
the characterization print routine PRTCHAR.BAS and make sure a
printer is on line.   The sequence of commands to print the
characterization and oil-weathering specifications will appear as
follows:

```
GWBASIC (enter)
KEY OFF (enter)
LOAD"PRTCHAR (enter)
RUN (enter)
```

The code PRTCHAR will prompt for the characterization file to be
printed; in this illustration enter GIBTCHR.ASC (from above), and
the results will be printed. Note that if a DOS-text disk file is
desired, load "PRTCHARF (with no period). The characterization
results will then be printed; for this illustration the results are
presented in Table 16.

To print the oil-weathering calculation results with Basic
still loaded, first enter NEW (to clear out the previous program)
and LOAD"PRTRSLT (with no period). Enter RUN and this code will
read the OILWIND intermediate output file and print the results.
Again, if a DOS-text disk file is desired LOAD"PRTRSLTF (with no
period).   The calculation results for this illustration are
presented in Tables 17a and 17b. The calculation results are
printed in two sets as indicated. The "a" set of results contains
the wind-speed data used. For this illustration note that the
initial hourly wind speeds in meters per second are 4.6, 2.5,
3.2,....., and that these correspond to the specified entries in
Table 15 starting at entry 30. Next note that at 21 hours of
weathering the wind speeds repeat, or loop back. The "norther"

occurred in the oil-weathering calculation at approximately 10 hours elapsed time. The rest of the output in Table 17a is explained in the header.

The "b" set of results in Table 17b contain additional weathering information as a function of time which are explained in the header. It is important to note the composition indices designated as "I" and "J" in these results. These indices give an indication of the slick composition. I is the first cut with greater than 5% of its initial mass remaining in the slick; likewise J corresponds to the first cut with greater than 50% of its initial mass remaining. The code searches for these indices according to the way the cuts are stored: from the most volatile to the least volatile. Also, note that at time equal zero, the start, that cut one(1) does not exist. This cut is so volatile at the weathering temperature of 70°F that it will evaporate in minutes and the code has deleted it. This cut's mass has not been deleted from the total material balance of the slick.

It is important to be able to identify the various results and different pages of hard copy. The identification is done uniquely with the recorded time of the calculation; this time is printed on every page so that every page can always be uniquely identified.

Table 15.   Illustration of a Wind-Speed Table used by the Variable
            Wind-Speed Open-Ocean Oil-Weathering Code (This table
            includes the passage of two cold fronts at approximately
            40 and 239 elapsed hours.)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 1
1	16.1	8.3	1.0	1.0	
2	17.3	8.9	1.0	2.0	
3	16.9	8.7	1.0	3.0	
4	17.5	9.0	1.0	4.0	
5	16.3	8.4	1.0	5.0	
6	17.9	9.2	1.0	6.0	
7	18.1	9.3	1.0	7.0	
8	18.3	9.4	1.0	8.0	
9	19.6	10.1	1.0	9.0	
10	16.5	8.5	1.0	10.0	
11	15.7	8.1	1.0	11.0	
12	14.4	7.4	1.0	12.0	
13	14.8	7.6	1.0	13.0	
14	15.4	7.9	1.0	14.0	
15	13.0	6.7	1.0	15.0	
16	13.6	7.0	1.0	16.0	
17	14.2	7.3	1.0	17.0	
18	14.6	7.5	1.0	18.0	
19	15.6	8.0	1.0	19.0	
20	15.6	8.0	1.0	20.0	
21	15.7	8.1	1.0	21.0	
22	15.6	8.0	1.0	22.0	
23	14.0	7.2	1.0	23.0	
24	13.8	7.1	1.0	24.0	
25	13.2	6.8	1.0	25.0	
26	12.4	6.4	1.0	26.0	
27	11.1	5.7	1.0	27.0	
28	13.4	6.9	1.0	28.0	
29	9.5	4.9	1.0	29.0	
30	8.9	4.6	1.0	30.0	
31	4.9	2.5	1.0	31.0	
32	6.2	3.2	1.0	32.0	
33	8.6	4.4	1.0	33.0	
34	6.8	3.5	1.0	34.0	
35	6.2	3.2	1.0	35.0	
36	11.9	6.1	1.0	36.0	

Table 15. Illustration of a Wind-Speed Table used by the Variable
Wind-Speed Open-Ocean Oil-Weathering Code (This table
includes the passage of two cold fronts at approximately
40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 2
37	10.1	5.2	1.0	37.0	
38	12.6	6.5	1.0	38.0	
39	17.9	9.2	1.0	39.0	
40	19.2	9.9	1.0	40.0	
41	16.1	8.3	1.0	41.0	
42	18.1	9.3	1.0	42.0	
43	16.5	8.5	1.0	43.0	
44	20.8	10.7	1.0	44.0	
45	20.4	10.5	1.0	45.0	
46	19.6	10.1	1.0	46.0	
47	17.9	9.2	1.0	47.0	
48	17.9	9.2	1.0	48.0	
49	17.7	9.1	1.0	49.0	
50	16.1	8.3	1.0	50.0	
51	17.9	9.2	1.0	51.0	
52	17.5	9.0	1.0	52.0	
53	16.5	8.5	1.0	53.0	
54	14.2	7.3	1.0	54.0	
55	14.2	7.3	1.0	55.0	
56	15.9	8.2	1.0	56.0	
57	15.4	7.9	1.0	57.0	
58	16.1	8.3	1.0	58.0	
59	17.1	8.8	1.0	59.0	
60	20.4	10.5	1.0	60.0	
61	20.8	10.7	1.0	61.0	
62	20.8	10.7	1.0	62.0	
63	20.2	10.4	1.0	63.0	
64	20.8	10.7	1.0	64.0	
65	20.4	10.5	1.0	65.0	
66	19.4	10.0	1.0	66.0	
67	23.1	11.9	1.0	67.0	
68	23.1	11.9	1.0	68.0	
69	23.3	12.0	1.0	69.0	
70	24.1	12.4	1.0	70.0	
71	22.4	11.5	1.0	71.0	
72	24.3	12.5	1.0	72.0	

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Table 15.   Illustration of a Wind-Speed Table used by the Variable
            Wind-Speed Open-Ocean Oil-Weathering Code (This table
            includes the passage of two cold fronts at approximately
            40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 3
73	23.3	12.0	1.0	73.0	
74	25.1	12.9	1.0	74.0	
75	25.9	13.3	1.0	75.0	
76	25.1	12.9	1.0	76.0	
77	25.3	13.0	1.0	77.0	
78	25.3	13.0	1.0	78.0	
79	25.3	13.0	1.0	79.0	
80	24.1	12.4	1.0	80.0	
81	23.5	12.1	1.0	81.0	
82	23.3	12.0	1.0	82.0	
83	23.3	12.0	1.0	83.0	
84	22.9	11.8	1.0	84.0	
85	24.5	12.6	1.0	85.0	
86	23.5	12.1	1.0	86.0	
87	21.8	11.2	1.0	87.0	
88	23.3	12.0	1.0	88.0	
89	20.8	10.7	1.0	89.0	
90	19.6	10.1	1.0	90.0	
91	19.1	9.8	1.0	91.0	
92	17.1	8.8	1.0	92.0	
93	15.0	7.7	1.0	93.0	
94	14.4	7.4	1.0	94.0	
95	13.4	6.9	1.0	95.0	
96	13.8	7.1	1.0	96.0	
97	11.7	6.0	1.0	97.0	
98	13.6	7.0	1.0	98.0	
99	11.5	5.9	1.0	99.0	
100	9.5	4.9	1.0	100.0	
101	7.8	4.0	1.0	101.0	
102	5.1	2.6	1.0	102.0	
103	5.4	2.8	1.0	103.0	
104	4.5	2.3	1.0	104.0	
105	5.4	2.8	1.0	105.0	
106	0.0	0.0	1.0	106.0	
107	7.8	4.0	1.0	107.0	
108	7.6	3.9	1.0	108.0	

Table 15.   Illustration of a Wind-Speed Table used by the Variable
            Wind-Speed Open-Ocean Oil-Weathering Code (This table
            includes the passage of two cold fronts at approximately
            40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 4
109	9.5	4.9	1.0	109.0	
110	10.9	5.6	1.0	110.0	
111	9.5	4.9	1.0	111.0	
112	11.7	6.0	1.0	112.0	
113	13.2	6.8	1.0	113.0	
114	11.9	6.1	1.0	114.0	
115	11.3	5.8	1.0	115.0	
116	10.9	5.6	1.0	116.0	
117	11.3	5.8	1.0	117.0	
118	13.2	6.8	1.0	118.0	
119	12.6	6.5	1.0	119.0	
120	13.8	7.1	1.0	120.0	
121	15.2	7.8	1.0	121.0	
122	13.0	6.7	1.0	122.0	
123	14.8	7.6	1.0	123.0	
124	14.2	7.3	1.0	124.0	
125	16.5	8.5	1.0	125.0	
126	13.8	7.1	1.0	126.0	
127	14.0	7.2	1.0	127.0	
128	16.9	8.7	1.0	128.0	
129	15.4	7.9	1.0	129.0	
130	15.4	7.9	1.0	130.0	
131	16.7	8.6	1.0	131.0	
132	15.7	8.1	1.0	132.0	
133	17.7	9.1	1.0	133.0	
134	16.7	8.6	1.0	134.0	
135	15.9	8.2	1.0	135.0	
136	15.6	8.0	1.0	136.0	
137	17.7	9.1	1.0	137.0	
138	18.1	9.3	1.0	138.0	
139	18.5	9.5	1.0	139.0	
140	19.4	10.0	1.0	140.0	
141	18.9	9.7	1.0	141.0	
142	18.7	9.6	1.0	142.0	
143	20.0	10.3	1.0	143.0	
144	21.2	10.9	1.0	144.0	

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Table 15.   Illustration of a Wind-Speed Table used by the Variable
            Wind-Speed Open-Ocean Oil-Weathering Code (This table
            includes the passage of two cold fronts at approximately
            40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 5
145	18.9	9.7	1.0	145.0	
146	21.0	10.8	1.0	146.0	
147	19.1	9.8	1.0	147.0	
148	19.4	10.0	1.0	148.0	
149	22.4	11.5	1.0	149.0	
150	23.7	12.2	1.0	150.0	
151	23.1	11.9	1.0	151.0	
152	12.2	6.3	1.0	152.0	
153	10.3	5.3	1.0	153.0	
154	7.4	3.8	1.0	154.0	
155	9.1	4.7	1.0	155.0	
156	11.7	6.0	1.0	156.0	
157	4.7	2.4	1.0	157.0	
158	2.5	1.3	1.0	158.0	
159	2.7	1.4	1.0	159.0	
160	6.0	3.1	1.0	160.0	
161	9.1	4.7	1.0	161.0	
162	11.5	5.9	1.0	162.0	
163	7.6	3.9	1.0	163.0	
164	10.7	5.5	1.0	164.0	
165	10.9	5.6	1.0	165.0	
166	12.1	6.2	1.0	166.0	
167	12.2	6.3	1.0	167.0	
168	11.9	6.1	1.0	168.0	
169	10.7	5.5	1.0	169.0	
170	11.5	5.9	1.0	170.0	
171	11.7	6.0	1.0	171.0	
172	10.3	5.3	1.0	172.0	
173	10.9	5.6	1.0	173.0	
174	10.5	5.4	1.0	174.0	
175	11.3	5.8	1.0	175.0	
176	10.3	5.3	1.0	176.0	
177	8.9	4.6	1.0	177.0	
178	8.9	4.6	1.0	178.0	
179	8.4	4.3	1.0	179.0	
180	7.8	4.0	1.0	180.0	

Table 15.   Illustration of a Wind-Speed Table used by the Variable
            Wind-Speed Open-Ocean Oil-Weathering Code (This table
            includes the passage of two cold fronts at approximately
            40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 6
181	8.2	4.2	1.0	181.0	
182	9.1	4.7	1.0	182.0	
183	10.1	5.2	1.0	183.0	
184	9.7	5.0	1.0	184.0	
185	10.5	5.4	1.0	185.0	
186	9.3	4.8	1.0	186.0	
187	9.7	5.0	1.0	187.0	
188	11.5	5.9	1.0	188.0	
189	10.5	5.4	1.0	189.0	
190	10.9	5.6	1.0	190.0	
191	10.1	5.2	1.0	191.0	
192	7.6	3.9	1.0	192.0	
193	9.7	5.0	1.0	193.0	
194	11.1	5.7	1.0	194.0	
195	14.6	7.5	1.0	195.0	
196	15.0	7.7	1.0	196.0	
197	16.3	8.4	1.0	197.0	
198	15.6	8.0	1.0	198.0	
199	14.2	7.3	1.0	199.0	
200	13.6	7.0	1.0	200.0	
201	15.2	7.8	1.0	201.0	
202	12.1	6.2	1.0	202.0	
203	11.9	6.1	1.0	203.0	
204	12.2	6.3	1.0	204.0	
205	10.9	5.6	1.0	205.0	
206	12.1	6.2	1.0	206.0	
207	10.5	5.4	1.0	207.0	
208	10.9	5.6	1.0	208.0	
209	10.3	5.3	1.0	209.0	
210	10.5	5.4	1.0	210.0	
211	12.2	6.3	1.0	211.0	
212	9.9	5.1	1.0	212.0	
213	9.1	4.7	1.0	213.0	
214	9.1	4.7	1.0	214.0	
215	9.3	4.8	1.0	215.0	
216	8.9	4.6	1.0	216.0	

Table 15. Illustration of a Wind-Speed Table used by the Variable
           Wind-Speed Open-Ocean Oil-Weathering Code (This table
           includes the passage of two cold fronts at approximately
           40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 7
217	9.3	4.8	1.0	217.0	
218	10.1	5.2	1.0	218.0	
219	13.2	6.8	1.0	219.0	
220	12.1	6.2	1.0	220.0	
221	12.4	6.4	1.0	221.0	
222	9.9	5.1	1.0	222.0	
223	10.5	5.4	1.0	223.0	
224	9.7	5.0	1.0	224.0	
225	11.7	6.0	1.0	225.0	
226	10.9	5.6	1.0	226.0	
227	6.8	3.5	1.0	227.0	
228	8.6	4.4	1.0	228.0	
229	11.5	5.9	1.0	229.0	
230	11.1	5.7	1.0	230.0	
231	11.1	5.7	1.0	231.0	
232	10.9	5.6	1.0	232.0	
233	13.0	6.7	1.0	233.0	
234	10.5	5.4	1.0	234.0	
235	5.8	3.0	1.0	235.0	
236	3.3	1.7	1.0	236.0	
237	1.4	0.7	1.0	237.0	
238	1.4	0.7	1.0	238.0	
239	23.5	12.1	1.0	239.0	
240	23.9	12.3	1.0	240.0	
241	25.3	13.0	1.0	241.0	
242	26.0	13.4	1.0	242.0	
243	24.3	12.5	1.0	243.0	
244	23.3	12.0	1.0	244.0	
245	22.2	11.4	1.0	245.0	
246	21.4	11.0	1.0	246.0	
247	19.8	10.2	1.0	247.0	
248	20.0	10.3	1.0	248.0	
249	20.2	10.4	1.0	249.0	
250	19.1	9.8	1.0	250.0	
251	19.4	10.0	1.0	251.0	
252	18.1	9.3	1.0	252.0	

Table 15. Illustration of a Wind-Speed Table used by the Variable
          Wind-Speed Open-Ocean Oil-Weathering Code (This table
          includes the passage of two cold fronts at approximately
          40 and 239 elapsed hours.) (continued)

Wind-Speed Table printed by: WSPRINTF.BAS, version 2-13-92 1509
The file: A:GM19DE21.A90 was read at 19:49:32 on 05-28-1992

The identification string is: 42019 at 12/21/90 for 264 hrs

Entry #	Knots	Meters/sec	Duration Hours	Elapsed Hours	Page 8
253	18.5	9.5	1.0	253.0	
254	16.3	8.4	1.0	254.0	
255	16.3	8.4	1.0	255.0	
256	16.5	8.5	1.0	256.0	
257	16.9	8.7	1.0	257.0	
258	16.1	8.3	1.0	258.0	
259	15.4	7.9	1.0	259.0	
260	15.2	7.8	1.0	260.0	
261	15.9	8.2	1.0	261.0	
262	16.5	8.5	1.0	262.0	
263	15.2	7.8	1.0	263.0	
264	14.8	7.6	1.0	264.0	

Table 16. Oil-Characterization and Oil-Weathering Specifications
          for Illustration of the Weathering of Gibson Terminal
          Composite

OIL WEATHERING FOR: Gibson Terminal
CODE NAME IS CUTVPW.BAS, PRINTED BY PRTCHARF.BAS
RUN TIME IS 09:03:37 HOURS ON 09-26-1992

OIL VOLUME (SPILL), BARRELS = 1.00E+03, MEAN MOLE WEIGHT = 224
TEMPERATURE, DEGREES F = 70

THE WIND-SPEED TABLE CAME FROM THE FILE GM19DE21.A90
THE STARTING WIND ENTRY USED IS > 30
THE ENDING WIND ENTRY USED IS >>> 50
THE LOOP BACK WIND ENTRY IS >>>>> 30

FOR THE OUTPUT THAT FOLLOWS, MOLES = GRAM MOLES
GMS = GRAMS, VP = VAPOR PRESSURE IN ATMOSPHERES
BP = BOILING POINT IN DEGREES F, API = GRAVITY
MW = MOLECULAR WEIGHT

CUT	MOLES	GMS	VP	BP	API	MW
1	2.15E+04	1.70E+06	2.52E-01	1.34E+02	7.62E+01	7.90E+01
2	1.09E+05	1.07E+07	4.18E-02	2.10E+02	5.85E+01	9.80E+01
3	8.45E+04	1.09E+07	2.55E-03	3.08E+02	5.01E+01	1.29E+02
4	4.64E+04	7.10E+06	2.65E-04	3.76E+02	4.52E+01	1.53E+02
5	1.19E+05	2.15E+07	1.88E-05	4.50E+02	3.85E+01	1.81E+02
6	6.95E+04	1.54E+07	3.40E-07	5.50E+02	3.24E+01	2.22E+02
7	3.59E+04	9.45E+06	9.92E-09	6.25E+02	2.92E+01	2.63E+02
8	3.23E+04	1.01E+07	1.57E-10	7.00E+02	2.71E+01	3.14E+02
9	7.79E+04	4.68E+07	0.00E+00	8.50E+02	2.00E+01	6.00E+02

BULK API GRAVITY = 34.5, SPGR = 0.852
BULK CRUDE VISCOSITY, CENTIPOISE = 7.46E+01
VISCOSITY CONSTANT FOR FRACTION-OIL-WEATHERED = 1.05E+01
VISCOSITY-TEMPERATURE SCALING CONSTANT (ANDRADA) = 9.00E+03
MAXIMUM FRACTION WATER IN OIL (MOUSSE) = 0.70
MOUSSE-VISCOSITY CONSTANT = 0.65
MOUSSE WATER-INCORPORATION RATE CONSTANT = 1.00E-03
OIL/WATER SURFACE TENSION, DYNES/CM = 30.0
DISPERSION CONSTANTS ARE: AK = 1.08E-01, BK = 5.00E+01

Table 17a.   Oil-Weathering Calculation Results for Gibson Terminal
             Composite (First set of results, output is uniquely
             identified by the run time and date.)

OIL WEATHERING OUTPUT AT 09:03:37 HOURS ON 09-26-1992,   Page 1

CODE NAME IS PRTRSLTF.BAS

FOR OUTPUT BELOW THE FOLLOWING NOTATION APPLIES

TIME IS HOURS
WIND IS THE WIND SPEED IN METERS/SECOND
FRACTION IS MASS FRACTION REMAINING IN THE SLICK
SPGR IS THE SPECIFIC GRAVITY
AREA IS THE SLICK AREA IN METER*METER
THICKNESS IS THE SLICK THICKNESS IN CM
MOLE WT IS THE MEAN MOLECULAR WEIGHT OF THE SLICK
VISC IS THE VISCOSITY IN CP

TIME	WIND	FRACTION	SPGR	AREA	THICK	MOLE WT	VISC
0	4.6	0.99	0.84	7.8E+03	2.0E+00	229.8	1.3E+02
1	2.5	0.92	0.85	3.0E+04	4.7E-01	252.5	2.6E+02
2	3.2	0.90	0.86	4.2E+04	3.4E-01	262.0	3.4E+02
3	4.4	0.88	0.86	5.2E+04	2.6E-01	268.1	4.6E+02
4	3.5	0.87	0.86	5.7E+04	2.4E-01	271.6	5.1E+02
5	3.2	0.85	0.86	6.3E+04	2.1E-01	275.1	5.9E+02
6	6.1	0.84	0.86	6.9E+04	1.9E-01	278.1	9.9E+02
7	5.2	0.83	0.86	7.3E+04	1.8E-01	282.4	1.1E+03
8	6.5	0.82	0.86	7.8E+04	1.6E-01	286.1	1.8E+03
9	9.2	0.81	0.87	8.2E+04	1.5E-01	289.1	5.1E+03
10	9.9	0.79	0.87	8.6E+04	1.4E-01	292.6	9.2E+03
11	8.3	0.78	0.87	8.9E+04	1.3E-01	294.8	6.6E+03
12	9.3	0.77	0.87	9.3E+04	1.3E-01	296.6	1.3E+04
13	8.5	0.77	0.87	9.6E+04	1.2E-01	297.9	1.1E+04
14	10.7	0.76	0.87	1.0E+05	1.2E-01	299.5	3.1E+04
15	10.5	0.75	0.87	1.0E+05	1.1E-01	300.8	3.4E+04
16	10.1	0.75	0.87	1.1E+05	1.1E-01	302.0	3.6E+04
17	9.2	0.74	0.87	1.1E+05	1.0E-01	303.1	3.3E+04
18	9.2	0.74	0.87	1.1E+05	1.0E-01	304.1	3.8E+04
19	9.1	0.73	0.87	1.1E+05	9.9E-02	305.1	4.2E+04
20	8.3	0.73	0.87	1.2E+05	9.6E-02	306.0	3.7E+04
21	4.6	0.72	0.87	1.2E+05	9.4E-02	306.9	7.0E+03
22	2.5	0.72	0.87	1.2E+05	9.2E-02	307.4	3.6E+03
23	3.2	0.72	0.87	1.2E+05	9.0E-02	307.8	4.6E+03
24	4.4	0.72	0.87	1.3E+05	8.8E-02	308.2	8.1E+03
25	3.5	0.71	0.87	1.3E+05	8.6E-02	308.7	5.8E+03
26	3.2	0.71	0.87	1.3E+05	8.4E-02	309.1	5.5E+03
27	6.1	0.71	0.87	1.3E+05	8.3E-02	309.5	2.7E+04
28	5.2	0.71	0.87	1.3E+05	8.1E-02	310.2	1.8E+04
29	6.5	0.70	0.87	1.4E+05	7.9E-02	310.7	4.2E+04

Table 17a. Oil-Weathering Calculation Results for Gibson Terminal
Composite (First set of results, output is uniquely
identified by the run time and date.) (continued)

OIL WEATHERING OUTPUT AT 09:03:37 HOURS ON 09-26-1992,   Page 2

CODE NAME IS PRTRSLTF.BAS

FOR OUTPUT BELOW THE FOLLOWING NOTATION APPLIES

TIME IS HOURS
WIND IS THE WIND SPEED IN METERS/SECOND
FRACTION IS MASS FRACTION REMAINING IN THE SLICK
SPGR IS THE SPECIFIC GRAVITY
AREA IS THE SLICK AREA IN METER*METER
THICKNESS IS THE SLICK THICKNESS IN CM
MOLE WT IS THE MEAN MOLECULAR WEIGHT OF THE SLICK
VISC IS THE VISCOSITY IN CP

TIME	WIND	FRACTION	SPGR	AREA	THICK	MOLE WT	VISC
30	9.2	0.70	0.87	1.4E+05	7.8E-02	311.4	8.3E+04
31	9.9	0.70	0.87	1.4E+05	7.6E-02	312.2	8.8E+04
32	8.3	0.69	0.87	1.4E+05	7.4E-02	313.4	9.3E+04
33	9.3	0.69	0.87	1.4E+05	7.3E-02	314.1	1.0E+05
34	8.5	0.68	0.87	1.5E+05	7.2E-02	314.8	1.0E+05
35	10.7	0.68	0.87	1.5E+05	7.0E-02	315.4	1.1E+05
36	10.5	0.68	0.87	1.5E+05	6.9E-02	316.2	1.2E+05
37	10.1	0.67	0.87	1.5E+05	6.8E-02	316.9	1.2E+05
38	9.2	0.67	0.87	1.5E+05	6.7E-02	317.5	1.3E+05
39	9.2	0.67	0.87	1.5E+05	6.6E-02	318.1	1.4E+05
40	9.1	0.66	0.87	1.6E+05	6.5E-02	318.7	1.4E+05
41	8.3	0.66	0.87	1.6E+05	6.4E-02	319.3	1.5E+05
42	4.6	0.66	0.87	1.6E+05	6.3E-02	319.8	4.6E+04
43	2.5	0.66	0.87	1.6E+05	6.2E-02	320.2	1.2E+04
44	3.2	0.65	0.87	1.6E+05	6.2E-02	320.4	1.9E+04
45	4.4	0.65	0.88	1.6E+05	6.1E-02	320.6	4.7E+04
46	3.5	0.65	0.88	1.7E+05	6.0E-02	320.9	2.5E+04
47	3.2	0.65	0.88	1.7E+05	6.0E-02	321.2	2.2E+04
48	6.1	0.65	0.88	1.7E+05	5.9E-02	321.5	1.5E+05
49	5.2	0.65	0.88	1.7E+05	5.8E-02	321.9	1.1E+05
50	6.5	0.65	0.88	1.7E+05	5.8E-02	322.2	1.8E+05
51	9.2	0.64	0.88	1.7E+05	5.7E-02	322.7	1.9E+05
61	9.1	0.61	0.88	1.9E+05	5.0E-02	328.7	3.0E+05
71	6.5	0.59	0.88	2.0E+05	4.6E-02	332.3	4.2E+05
81	9.2	0.58	0.88	2.1E+05	4.2E-02	338.3	5.6E+05
91	5.2	0.56	0.88	2.2E+05	3.9E-02	342.3	7.7E+05
96	9.3	0.55	0.88	2.2E+05	3.8E-02	342.3	7.7E+05

Table 17b. Oil-Weathering Calculation Results for Gibson Terminal
Composite (Second set of results, output is uniquely
identified by the run time and date.)

OIL WEATHERING OUTPUT AT 09:03:37 HOURS ON 09-26-1992,   Page 3

CODE NAME IS PRTRSLTF.BAS

FOR THE OUTPUT BELOW THE FOLLOWING NOTATION APPLIES

TIME IS HOURS
MOUSSE IS THE MASS FRACTION WATER IN THE OIL + WATER
TOTAL-MASS IS THE METRIC-TON MASS OF OIL IN THE SLICK
F-EVAP IS THE MASS FRACTION EVAPORATED INTO THE ATMOSPHERE
F-DISP IS THE MASS FRACTION DISPERSED INTO THE WATER COLUMN
I IS THE FIRST CUT WITH GREATER THAN 5% OF INITIAL REMAINING
J IS THE FIRST CUT WITH GREATER THAN 50% OF INITIAL REMAINING

TIME	MOUSSE	TOTAL-MASS	F-EVAP	F-DISP	I	J
0	0.00	1.32E+02	0.00	0.00	2	2
1	0.01	1.23E+02	0.07	0.00	2	3
2	0.02	1.20E+02	0.09	0.00	2	3
3	0.06	1.17E+02	0.11	0.00	3	3
4	0.06	1.16E+02	0.12	0.01	3	3
5	0.06	1.14E+02	0.13	0.01	3	4
6	0.19	1.13E+02	0.14	0.01	3	4
7	0.19	1.11E+02	0.15	0.01	3	4
8	0.27	1.09E+02	0.16	0.02	3	4
9	0.48	1.08E+02	0.17	0.02	3	4
10	0.55	1.06E+02	0.17	0.02	3	4
11	0.55	1.05E+02	0.18	0.03	4	4
12	0.57	1.03E+02	0.18	0.03	4	4
13	0.57	1.03E+02	0.19	0.03	4	4
14	0.67	1.01E+02	0.19	0.04	4	4
15	0.68	1.01E+02	0.20	0.04	4	5
16	0.68	9.99E+01	0.20	0.04	4	5
17	0.68	9.91E+01	0.20	0.05	4	5
18	0.68	9.85E+01	0.21	0.05	4	5
19	0.68	9.78E+01	0.21	0.05	4	5
20	0.68	9.72E+01	0.21	0.05	4	5
21	0.68	9.67E+01	0.21	0.05	4	5
22	0.68	9.63E+01	0.22	0.05	4	5
23	0.68	9.61E+01	0.22	0.06	4	5
24	0.68	9.58E+01	0.22	0.06	4	5
25	0.68	9.54E+01	0.22	0.06	4	5
26	0.68	9.51E+01	0.22	0.06	4	5
27	0.68	9.48E+01	0.22	0.06	4	5
28	0.68	9.44E+01	0.22	0.06	4	5

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Table 17b. Oil-Weathering Calculation Results for Gibson Terminal
           Composite (Second set of results, output is uniquely
           identified by the run time and date.) (continued)

OIL WEATHERING OUTPUT AT 09:03:37 HOURS ON 09-26-1992,   Page 4

CODE NAME IS PRTRSLTF.BAS

FOR THE OUTPUT BELOW THE FOLLOWING NOTATION APPLIES

TIME IS HOURS
MOUSSE IS THE MASS FRACTION WATER IN THE OIL + WATER
TOTAL-MASS IS THE METRIC-TON MASS OF OIL IN THE SLICK
F-EVAP IS THE MASS FRACTION EVAPORATED INTO THE ATMOSPHERE
F-DISP IS THE MASS FRACTION DISPERSED INTO THE WATER COLUMN
I IS THE FIRST CUT WITH GREATER THAN 5% OF INITIAL REMAINING
J IS THE FIRST CUT WITH GREATER THAN 50% OF INITIAL REMAINING

TIME	MOUSSE	TOTAL-MASS	F-EVAP	F-DISP	I	J
29	0.68	9.40E+01	0.22	0.06	4	5
30	0.70	9.36E+01	0.23	0.06	4	5
31	0.70	9.31E+01	0.23	0.07	4	5
32	0.70	9.23E+01	0.23	0.07	4	5
33	0.70	9.18E+01	0.23	0.07	4	5
34	0.70	9.14E+01	0.23	0.07	4	5
35	0.70	9.09E+01	0.24	0.07	4	5
36	0.70	9.04E+01	0.24	0.08	4	5
37	0.70	8.99E+01	0.24	0.08	5	5
38	0.70	8.94E+01	0.24	0.08	5	5
39	0.70	8.90E+01	0.24	0.08	5	5
40	0.70	8.86E+01	0.25	0.08	5	5
41	0.70	8.82E+01	0.25	0.08	5	5
42	0.70	8.78E+01	0.25	0.09	5	5
43	0.70	8.76E+01	0.25	0.09	5	5
44	0.70	8.75E+01	0.25	0.09	5	5
45	0.70	8.73E+01	0.25	0.09	5	5
46	0.70	8.71E+01	0.25	0.09	5	5
47	0.70	8.69E+01	0.25	0.09	5	5
48	0.70	8.67E+01	0.25	0.09	5	5
49	0.70	8.65E+01	0.25	0.09	5	5
50	0.70	8.63E+01	0.25	0.09	5	5
51	0.70	8.60E+01	0.26	0.09	5	5
61	0.70	8.21E+01	0.27	0.11	5	5
71	0.70	7.94E+01	0.28	0.12	5	6
81	0.70	7.69E+01	0.29	0.13	5	6
91	0.70	7.45E+01	0.30	0.14	5	6
96	0.70	7.36E+01	0.30	0.14	5	6

USER'S INSTRUCTIONS: CREATING A WIND-SPEED FILE

A wind-speed file can be created or edited using the Basic code WSPEED.BAS in the interpreted or compiled mode. This code is completely user interactive and displays the wind-speed file to the user in increments that fit on the monitor. The edit commands available include delete, insert or change an entry, and continue to the next screen or finish. When creating a wind-speed file the user will usually experience input errors. When this occurs the user should finish entering the data and then edit the new file after it is initially stored. This is accomplished by rerunning the code and entering the new file name when prompted to do so.

There are two other Basic utilities to aid the user in creating wind-speed files. These are WSPEED1.BAS which is exactly like WSPEED.BAS except that this code expects the wind-speed data to be spaced by one hour every time, and alleviates the user from having to enter one(1) every time. This code is quite useful when entering data from the Gulf of Mexico buoys. The other code is WSPACK.BAS which concatenates two wind-speed files to create a new one. All of these Basic utility codes are completely user interactive.

These Basic utility codes were used to create wind-speed files from the available MMS data (Brown 1991); these wind-speed files are identified in Table 18 and contain approximately 8,000 hours of data from the Gulf of Mexico buoys identified as stations 42019 ("LaNelle") and 42020 ("Eileen"). The disk files in this table can be read directly by the oil-weathering specification code CUTVPW.BAS.

Table 18. Disk-File Index for the Wind-Speed Data Files for Data
from the Gulf of Mexico Buoys Identified as Stations
42019 and 42020 (Brown 1991) (These wind-speed files are
read by the oil-weathering code and used to specify the
wind speed as a function of time.)

File Name	Buoy ID	Start Date	Hours
GM19JA01.A91	42019	1/1/91	192
GM19JA09.A91	42019	1/9/91	192
GM19JA17.A91	42019	1/17/91	192
GM19JA25.A91	42019	1/25/91	168
GM19FE01.A91	42019	2/1/91	192
GM19FE09.A91	42019	2/9/91	192
GM19FE17.A91	42019	2/17/91	192
GM19FE25.A91	42019	2/25/91	96
GM19MA01.A91	42019	3/1/91	192
GM19MA09.A91	42019	3/9/91	192
GM19MA17.A91	42019	3/17/91	192
GM19MA25.A91	42019	3/25/91	168
GM20AP01.A91	42020	4/1/91	288
GM20AP13.A91	42020	4/13/91	288
GM20AP25.A91	42020	4/25/91	216
GM20MY04.A91	42020	5/4/91	288
GM20MY16.A91	42020	5/16/91	312
GM20MY29.A91	42020	5/29/91	288
GM20JN10.A91	42020	6/10/91	288
GM20JN22.A91	42020	6/22/91	216
GM19AP01.A91	42019	4/1/91	288
GM19AP13.A91	42019	4/13/91	288
GM19AP25.A91	42019	4/25/91	240
GM19MY05.A91	42019	5/5/91	288
GM19MY17.A91	42019	5/17/91	288
GM19MY29.A91	42019	5/29/91	168
GM19JN05.A91(*)	42019	6/5/91	171
GM19JY01.A90	42019	7/1/90	192
GM19JY09.A90	42019	7/9/90	192
GM19JY17.A90	42019	7/17/90	192
GM19JY25.A90	42019	7/25/90	168
GM19AU01.A90	42019	8/1/90	192
GM19AU09.A90	42019	8/9/90	192
GM19AU17.A90	42019	8/17/90	192
GM19AU25.A90	42019	8/25/90	192

Table 18. Disk-File Index for the Wind-Speed Data Files for Data
from the Gulf of Mexico Buoys Identified as Stations
42019 and 42020 (Brown 1991) (These wind-speed files are
read by the oil-weathering code and used to specify the
wind speed as a function of time.) (continued)

File Name	Buoy ID	Start Date	Hours
GM19SE01.A90	42019	9/1/90	192
GM19SE09.A90	42019	9/9/90	192
GM19SE17.A90	42019	9/17/90	192
GM19SE25.A90	42019	9/25/90	144
GM19SE01.A91	42019	9/1/91	192
GM19SE09.A91	42019	9/9/91	192
GM19SE17.A91	42019	9/17/91	192
GM19SE25.A91	42019	9/25/91	144
GM19OC01.A90	42019	10/1/90	192
GM19OC09.A90	42019	10/9/90	144
GM19OC15.A90	42019	10/15/90	144
GM19OC21.A90	42019	10/21/90	216
GM19OC30.A90	42019	10/30/90	168
GM19NO06.A90	42019	11/6/90	144
GM19NO12.A90	42019	11/12/90	144
GM19NO18.A90	42019	11/18/90	192
GM19NO26.A90	42019	11/26/90	144
GM19DE02.A90	42019	12/2/90	192
GM19DE10.A90	42019	12/10/90	264
GM19DE21.A90	42019	12/21/90	264
GM20OC01.A90	42020	10/1/90	288
GM20OC18.A90(*)	42020	10/18/90	77
GM20NO07.A90	42020	11/7/90	216
GM20NO18.A90	42020	11/18/90	288
GM20NO30.A90	42020	11/30/90	216
GM20DE09.A90	42020	12/9/90	288
GM20DE21.A90	42020	12/21/90	264
GM20OC13.A90	42020	10/13/90	96

(*) indicates missing data in original printout.

USER'S INSTRUCTIONS: CREATING A PHYSICAL PROPERTY FILE

A physical property file can be created by using the Basic code CUTVPW.BAS in interpreted or compiled mode. The first prompt from this code asks the user if an existing physical property file is to be read or a new one is to be entered. Upon specifying that a new file is to be entered, a crude (or petroleum product) name will be requested, the number of true boiling point (TBP) cuts in this crude and then for each cut the boiling point in degrees Fahrenheit, the API gravity and the volume percent distilled. The user is cautioned on the monitor that a boiling point of $850^\circ F$ must be entered for a residuum if present. No boiling point higher than $850^\circ F$ can be processed by the code. The user need not be concerned about entering the exact volume percent distilled because the code will renormalize to 100%. For the situation where some of the distillation data are obtained at an absolute pressure of 40-mm Hg, the data can be entered without correction to one(1) atmosphere total pressure; the code will do this automatically. Most of the prompts that then follow will have suggested values that can be entered. The exception is the prompt for the maximum weight fraction water in oil for the oil-in-water emulsion. This fraction for crudes should be 0.6 to 0.7 and can range down to 0. For petroleum products this fraction must be 0. The code will then continue prompting for oil-weathering specification; continue entering this information. The last prompt will be for a file name to store the newly entered physical properties.

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APPENDIX A

CUTVPW Source Code Listing

Appendix A: CUTVPW Source Code Listing (Version of 5-28-92 @ 2028).

```
100 OPTION BASE 1
110 DEFINT I-N
120 DIM TB(18),API(18),VOL(18),AMOLES(18),VP(18),SPGR(18),A(18),B(18),TC(18)
130 DIM VC(18),PC(18),CNUM(18),T10(18),HVAP1(18),HVAPZ(18),CZ(2,6),TZ(2,6)
140 DIM PZ(4),AMTCA(18),AMTC(18),AMW(18),RHO(18),WS1(340),HOURS1(340)
150 DIM NS(18),NC(18),MW(18)
160 DEF FNYI(X)=((1!-X)^.38)/(X*X)
170 CODEN$="CUTVPW.BAS"
180 VER$="5-28-92 @ 2028"
190 REM SCAL CONVERTS LOGE TO LOG10
200 SCAL=.4342945
210 AK=.108:BK=50!
220 REM Set the viscosity-type parameter to centipoise.
230 TESTV$="C"
240 REM Set the viscosity-reporting temperature, it is always stored as
250 REM 25 Deg C, also 77 Deg F.
260 VISZT=25!
270 CLS
280 CZ(1,1)=62.41:CZ(1,2)=-.04595:CZ(1,3)=-.2836:CZ(1,4)=.003256
290 CZ(1,5)=.0004578:CZ(1,6)=.0005279:CZ(2,1)=426.8:CZ(2,2)=-1.007
300 CZ(2,3)=-7.449:CZ(2,4)=.0138:CZ(2,5)=.001047:CZ(2,6)=.02621
310 TZ(1,1)=405.5:TZ(1,2)=1.337:TZ(1,3)=-2.662:TZ(1,4)=-.002169
320 TZ(1,5)=-.0004943:TZ(1,6)=.01454:TZ(2,1)=412.2:TZ(2,2)=1.276
330 TZ(2,3)=-2.865:TZ(2,4)=-.002888:TZ(2,5)=-.0003707:TZ(2,6)=.02888
340 PZ(1)=.01237:PZ(2)=.2516:PZ(3)=.04039:PZ(4)=-.04024
350 REM The disk file use in the order they are used is as follows:
360 REM    #1 IS OIL-CHARACTERIZATION INPUT DATA SUCH AS TBP DISTILLATION,
370 REM       BULK API, VISCOSITY DATA.
380 REM    #2 IS OIL-CHARACTERIZATION INPUT DATA THAT WAS KEY-BOARDED IN
390 REM       AND THEN SAVED, CAN BE READ BY #1.
400 REM    #3 IS OIL-CHARACTERIZATION CALCULATED RESULTS AND OIL-WEATHERING
410 REM       INPUT DATA, THIS IS TO BE PRINTED AS THE 80-COLUMN FILE.
420 REM    #4 IS OIL CHARACTERIZATION CALCULATED RESULTS AND OIL-WEATHERING
430 REM       INPUT DATA, THIS IS TO BE PRINTED AS THE 132-COLUMN FILE.
431 REM The above file numbers are changed, retained for back reference.
440 REM Record the date and time of this calculation.
450 DTE$=DATE$
460 TME$=TIME$
465 PRINT:PRINT"Variable Wind-Speed Open-Ocean Oil-Weathering Code:";
466 PRINT" MMS 92-0023"
470 PRINT:PRINT"You can read(R) an existing oil-characterization file or";
480 PRINT" enter(E) the data"
490 INPUT"yourself and then save it.  What do you want to do ";AN$
500 TEST$=LEFT$(AN$,1)
510 IF TEST$="R" OR TEST$="r" GOTO 550
520 IF TEST$="E" OR TEST$="e" GOTO 570
530 PRINT:PRINT"Your entry was not read(R) or enter(E), do it again."
540 GOTO 470
550 IZ=1
560 GOTO 590
```

```
570 IZ=2
580 GOTO 790
590 REM NEDIT IS THE EDIT SWITCH, IF A DISK FILE IS READ AND THEN EDITED,
600 REM THE USER IS ASKED IF THE EDITED RESULTS ARE TO BE SAVED.
610 NEDIT=0
620 IF IZ=2 GOTO 790
630 REM READ IN OIL-CHARACTERIZATION DATA FROM A DISK FILE
640 PRINT:INPUT"Enter the oil-characterization file name";PFYL1$
650 REM IZ=1 IS USED TO INDICATE THAT A DISK FILE CRUDE WAS SPECIFIED
660 OPEN "I", #1, PFYL1$
670 INPUT #1, MWSCTH
680 INPUT #1, CNAME$
690 INPUT #1, NCUTS
700 FOR I = 1 TO NCUTS
710 INPUT #1, TB(I),API(I),VOL(I)
720 NEXT I
730 INPUT #1, APIB,VISZ,VK3,VK4
740 INPUT #1, C2,C1,C4,STEN
750 CLOSE #1
760 REM NOW GOSUB TO THE DISTILLATION EDITING ROUTINE
770 GOSUB 7250
780 GOTO 940
790 PRINT:INPUT"Enter the crude oil name";CNAME$
800 PRINT:INPUT"Enter the number of TPB cuts in this crude";NCUTS
810 PRINT:PRINT"You must now enter the TPB cut data starting with the most"
820 PRINT"volatile cut and then go to the bottom of the barrel."
830 PRINT"(If residuum is present, set its boiling point at 850 F.)"
840 FOR I=1 TO NCUTS
850 PRINT:PRINT"Enter the boiling point at 1 atm in deg F for cut";I
860 INPUT TB(I)
870 PRINT"Enter the API gravity for cut";I
880 INPUT API(I)
890 PRINT"Enter the volume % for cut";I
900 INPUT VOL(I)
910 NEXT I
920 REM NOW GOSUB TO THE DISTILLATION EDITING ROUTINE
930 GOSUB 7250
940 REM THE TBP DISTILLATION IS NOW IN AND EDITED
950 REM NOW ENTER THE REST OF THE VISCOSITY DATA
960 REM IF A DISK FILE WAS READ AS OIL INPUT, SKIP AROUND TO 1060
970 IF IZ=1 GOTO 1070
980 PRINT:INPUT"Enter the bulk crude API gravity";APIB
990 REM This change of September 23, 1991, allows the user to enter
1000 REM the viscosity in centipoise or Saybolt Seconds.
1010 GOSUB 7960
1020 PRINT:INPUT"Enter the viscosity-reporting temperature, Deg C.";VISZT
1030 PRINT:PRINT"Enter the viscosity temperature scaling constant, (Andrada)";
1040 INPUT", try 9000";VK3
1050 PRINT:PRINT"Enter the viscosity-fraction-oil-weathered constant";
1060 INPUT", try 10.5";VK4
1070 PRINT:PRINT"1. Bulk API = ";APIB
1080 IF TESTV$="S" OR TESTV$="s" GOTO 1110
```

```
1090 PRINT"2. Bulk viscosity, centipoise - ";VISZ
1100 GOTO 1120
1110 PRINT"2. Bulk viscosity, Saybolt Seconds - ";VISZ
1120 PRINT"3. Viscosity reporting temperature, Deg C. ";VISZT
1130 PRINT"4. Vis-temperature constant - ";VK3
1140 PRINT"5. Vis-fraction-oil-weathered constant = ";VK4
1150 PRINT:INPUT"Want to change any";AN$
1160 TEST$=LEFT$(AN$,1)
1170 IF TEST$="N" OR TEST$="n" GOTO 1380
1180 IF TEST$="Y" OR TEST$="y" GOTO 1210
1190 PRINT:PRINT"Expected yes or no, re-enter."
1200 GOTO 1150
1210 NEDIT=1
1220 PRINT:INPUT"Enter the line # to be changed";NLINE
1230 IF NLINE>=1 AND NLINE<=5 GOTO 1260
1240 PRINT:PRINT"Expected a number between 1 and 5, re-enter."
1250 GOTO 1220
1260 ON NLINE GOTO 1270,1290,1310,1330,1360
1270 PRINT:INPUT"Enter bulk API";APIB
1280 GOTO 1070
1290 GOSUB 7960
1300 GOTO 1070
1310 PRINT:INPUT"Enter the viscosity-reporting temperature, Deg C.";VISZT
1320 GOTO 1070
1330 PRINT:PRINT"Enter the viscosity-temperature scaling constant (Andrada)";
1340 INPUT", TRY 9000";VK3
1350 GOTO 1070
1360 PRINT:INPUT"Enter the vis-fraction-oil-weathered constant, try 10.5";VK4
1370 GOTO 1070
1380 REM Now check to see what viscosity units are being used.  If the
1390 REM units are centipoise, loop around.  If the units are Saybolt
1400 REM Seconds, convert to centipoise.
1410 IF TESTV$="C" OR TESTV$="c" GOTO 1460
1420 REM Fall throught to here means that Saybolt Seconds are to be
1430 REM converted to centipoise.  Note that Saybolt Seconds is a
1440 REM kinematic viscosity and must be multiplied by the density.
1450 VISZ=141.5*(.22*VISZ-179.3/VISZ)/(APIB+131.5)
1460 IF IZ=1 GOTO 1590
1470 PRINT:PRINT"Now enter the mousse formation data"
1480 PRINT:INPUT"Enter the maximum weight fraction water in oil";C2
1490 IF C2>0 GOTO 1560
1500 C2=-1
1510 C1=.65
1520 C4=.001
1530 PRINT:PRINT"Since 0% water-in-oil is specified, the emulsion constants";
1540 PRINT" are not needed"
1550 GOTO 1810
1560 PRINT:INPUT"Enter the mousse-viscosity constant, try 0.65";C1
1570 PRINT:INPUT"Enter the water incorporation rate constant, try 0.001";C4
1580 REM NOW ECHO THE ABOVE TO THE CRT
1590 PRINT:PRINT"1. Maximum weight fraction water in oil = ";C2
1600 PRINT"2. Mousse-viscosity constant - ";C1
```

```
1610 PRINT"3. Mousse water incorporation rate constant - ";C4
1620 PRINT:INPUT"Want to change any";AN$
1630 TEST$=LEFT$(AN$,1)
1640 IF TEST$="N" OR TEST$="n" GOTO 1800
1650 IF TEST$="Y" OR TEST$="y" GOTO 1680
1660 PRINT:PRINT"Expected yes or no, re-enter."
1670 GOTO 1620
1680 NEDIT=1
1690 PRINT:INPUT"Enter the line # to be changed";NLINE
1700 IF NLINE>=1 AND NLINE<=3 GOTO 1730
1710 PRINT:PRINT"Expected a number between 1 and 3, re-enter."
1720 GOTO 1690
1730 ON NLINE GOTO 1740,1760,1780
1740 PRINT:INPUT"Enter the maximum weight fraction water in oil";C2
1750 GOTO 1590
1760 PRINT:INPUT"Enter the mousse-viscosity constant, try 0.65";C1
1770 GOTO 1590
1780 PRINT:INPUT"Enter the water incorporation rate constant, try 0.001";C4
1790 GOTO 1590
1800 IF IZ=1 GOTO 1820
1810 PRINT:INPUT"Enter the oil/water surface tension, dynes/cm, try 30";STEN
1820 PRINT:PRINT"Oil/water surface tension, dynes/cm = ";STEN
1830 PRINT:INPUT"Want to change the surface tension";AN$
1840 TEST$=LEFT$(AN$,1)
1850 IF TEST$="N" OR TEST$="n" GOTO 1910
1860 IF TEST$="Y" OR TEST$="y" GOTO 1890
1870 PRINT:PRINT"Expected yes or no, re-enter."
1880 GOTO 1830
1890 NEDIT=1
1900 GOTO 1810
1910 PRINT:PRINT"Characterizing the cuts now."
1920 REM NOW CHARACTERIZED ALL THE CUTS.  IF THE LAST CUT IS RESIDUUM DO NOT
1930 REM CHARACTERIZE IT BUT USE A VAPOR PRESSURE OF 0. AND MOLECULAR WEIGHT
1940 REM OF 600.
1950 AMW(NCUTS)=600!
1960 MW(NCUTS)=600!
1970 VP(NCUTS)=0!
1980 REM NV=1 MEANS NO RESIDUUM PRESENT
1990 REM NV=2 MEANS RESIDUUM IS PRESENT
2000 NV=1
2010 NC1=NCUTS
2020 REM THIS FOR-NEXT LOOP CHARACTERIZES THE CUTS
2030 FOR I=1 TO NCUTS
2040 APIN=API(I)
2050 SPGR(I)=141.5/(API(I)+131.5)
2060 SPGR(I)=.983*SPGR(I)
2070 TBIN=TB(I)
2080 REM THE RESIDUUM CUT IS IDENTIFIED BY A NORMAL BOILING POINT OF 850
2090 REM DEG F OR GREATER.  LOOP AROUND THE NV=2 SWITCH IF A RESIDUUM IS
2100 REM PRESENT.  NC1 IS THE NUMBER OF PSEUDOCOMPONENTS PRESENT WITH FINITE
2110 REM VAPOR PRESSURES.
2120 IF TBIN<850! GOTO 2160
```

```
2130 NV=2
2140 NC1=NCUTS-1
2150 REM NOW GOSUB TO THE CUT CHARACTERIZATION ROUTINE
2160 GOSUB 6780
2170 ON NV GOTO 2180,2640
2180 NS(I)=NSN
2190 A(I)=AN
2200 B(I)=BN
2210 MW(I)=MW1
2220 AMW(I)=MW1
2230 TC(I)=TC1+459!
2240 VC(I)=VC1
2250 PC(I)=PC1
2260 CNUM(I)=CNUM1
2270 REM FIND THE TEMPERATURE AT WHICH THE VAPOR PRESSURE IS 10 MMHG BY
2280 REM USING NEWTON-RAPHSON WITH TB AS THE FIRST GUESS.
2290 NC(I)=0
2300 YTEN=SCAL*LOG(.01315/PC(I))
2310 X=(TB(I)+459!)/TC(I)
2320 EX=EXP(-20!*(X-B(I))^2)
2330 Y=-A(I)*(1!-X)/X-EX
2340 YOBJ=Y-YTEN
2350 VP(I)=PC(I)*10!^Y
2360 TEST=ABS(VP(I)-.01315)
2370 IF TEST<.001315 GOTO 2540
2380 NC(I)=NC(I)+1
2390 IF NC(I)>20 GOTO 2450
2400 DY=A(I)/(X*X)+40!*(X-B(I))*EX
2410 BI=YOBJ-DY*X
2420 X=-BI/DY
2430 GOTO 2320
2440 REM UNSUCCESSFUL EXIT FROM NEWTON-RAPHSON
2450 PRINT:PRINT"T10 FAILURE FOR ";
2460 PRINT USING"##";I;
2470 PRINT" AT T = ";
2480 PRINT USING"##.###^^^^";X;
2490 PRINT", WHERE LOG10(P) = ';
2500 PRINT USING"##.###^^^^";Y
2510 PRINT:PRINT"CODE IS STOPPED HERE."
2520 END
2530 REM SUCCESSFUL EXIT FROM NEWTON-RAPHSON
2540 T10(I)=X*TC(I)
2550 REM CALCULATE THE HEAT OF VAPORIZATION AT 10 MMHG WITH THE
2560 REM CLAPEYRON EQUATION AND USE WATSON'S METHOD FOR THE
2570 REM VAPOR PRESSURE BELOW 10 MMHG.  SEE GAMSON AND WATSON,
2580 REM 1944, NATIONAL PETROLEUM NEWS, R-258 TO R-264.
2590 TR2=T10(I)/TC(I)
2600 EX=92.12*(TR2-B(I))*EXP(-20!*(TR2-B(I))^2)
2610 HVAP=1.987*T10(I)*T10(I)*(2.303*A(I)/(TR2*TR2)+EX)/TC(I)
2620 HVAP1(I)=HVAP/MW(I)
2630 HVAPZ(I)=HVAP/(1!-TR2)^.38
2640 NEXT I
```

```
2650 REM END OF TRUE-BOILING-POINT CUTS CHARACTERIZATION
2660 PRINT:PRINT"Enter the temperature in deg F for the vapor pressure";
2670 INPUT" calculation";XSAVE
2680 DEGF=XSAVE
2690 REM TK IS THE ABSOLUTE TEMPERATURE IN DEG K
2700 TK=(XSAVE-32!)/1.8+273!
2710 XPRINT=XSAVE
2720 REM CALCULATE THE ABSOLUTE TEMPERATURE IN DEG RANKINE
2730 XSAVE=XSAVE+459!
2740 REM CALCULATE THE VAPOR PRESSURE AT THE INPUT TEMPERATURE
2750 REM
2760 REM AT THIS POINT IF THE INPUT TEMPERATURE IS LESS THAN
2770 REM THE 10-MMHG TEMPERATURE USE THE WATSON-CLAPEYRON EQUATION.
2780 REM THE WATSON-CLAPEYRON EQUATION IS:
2790 REM
2800 REM LN(P2/P1) = (HVAPZ/(R*TC))*INTEGRAL
2810 REM
2820 REM WHERE P1 = PRESSURE AT TR1, P2 = PRESSURE AT TR2, HVAPZ IS
2830 REM THE HEAT OF VAPORIZATION AT ABSOLUTE ZERO,
2840 REM R = 1.987 BTU/(LBMOLE, DEG R),
2850 REM TC = CRITICAL TEMPERATURE AND INTEGRAL = VAPORIZATION
2860 REM INTEGRAL BETWEEN TR1 AND TR2.
2870 REM
2880 FOR I = 1 TO NC1
2890 X=XSAVE
2900 IF X< T10(I) GOTO 2960
2910 X=X/TC(I)
2920 EX=EXP(-20!*(X-B(I))^2)
2930 Y=-A(I)*(1!-X)/X-EX
2940 VP(I)=PC(I)*10!^Y
2950 GOTO 3160
2960 TR1=X/TC(I)
2970 REM
2980 REM DO INTEGRAL BY SIMPSONS RULE WITH 21 POINTS
2990 REM
3000 TR2=T10(I)/TC(I)
3010 DH=(TR2-TR1)/20!
3020 RESULT=FNYI(TR1)
3030 TR=TR1
3040 FOR K=1 TO 10
3050 TR=TR+DH
3060 RESULT=RESULT+4!*FNYI(TR)
3070 TR=TR+DH
3080 RESULT=RESULT+2!*FNYI(TR)
3090 NEXT K
3100 TR=TR+DH
3110 RESULT=RESULT+4!*FNYI(TR)
3120 TR=TR+DH
3130 RESULT=DH*(RESULT+FNYI(TR))/3!
3140 P1=-4.33-HVAPZ(I)*RESULT/(1.987*TC(I))
3150 VP(I)=EXP(P1)
3160 NEXT I
```

```
3170 BBL=100!
3180 GOSUB 7790
3190 REM The switch MWSCTH=1 is left in because it is written on the files
3200 REM but not currently used (10-31-91).
3210 MWSCTH=1
3220 REM THIS ENDS THE OIL-CHARACTERIZTION SECTION, NOW BEGIN THE
3230 REM OIL-WEATHERING INPUT DATA.
3240 PRINT:INPUT"Enter the spill size in barrels";BBL
3250 PRINT:INPUT"Enter the number of hours for weathering to occur";X2
3260 PRINT:INPUT"Enter the wind file name";WPFYL$
3270 PRINT:INPUT"Want the slick to spread";AN$
3280 NSR=1
3290 TEST$=LEFT$(AN$,1)
3300 IF TEST$="Y" OR TEST$="y" GOTO 3370
3310 IF TEST$="N" OR TEST$="n" GOTO 3340
3320 PRINT:PRINT"Expected yes or no, re-enter."
3330 GOTO 3270
3340 NSR=2
3350 PRINT:PRINT"Since the slick does not spread, enter a thickness";
3360 INPUT" in cm";Z
3370 PRINT:INPUT"Want weathering with dispersion";AN$
3380 NDR=1
3390 TEST$=LEFT$(AN$,1)
3400 IF TEST$="Y" OR TEST$="y" GOTO 3450
3410 IF TEST$="N" OR TEST$="n" GOTO 3440
3420 PRINT:PRINT"Expected yes or no, re-enter."
3430 GOTO 3370
3440 NDR=2
3450 PRINT:PRINT"1. Spill size, barrels = ";
3460 PRINT USING"##.##^^^^";BBL
3470 PRINT"2. Duration of weathering, hours = ";
3480 PRINT USING"###.#";X2
3490 PRINT"3. Wind file name is ";WPFYL$
3500 ON NSR GOTO 3510,3530
3510 PRINT"4. The slick spreads."
3520 GOTO 3550
3530 PRINT"4. The slick does not spread, initial thickness, cm = ";
3540 PRINT USING"###.##";Z
3550 ON NDR GOTO 3560,3600
3560 PRINT"5. Dispersion occurs."
3570 PRINT"6. Dispersion rate constant, 1/hr = ";AK
3580 PRINT"7. Dispersion property constant = ";BK
3590 GOTO 3610
3600 PRINT"5. Dispersion does not occur."
3610 PRINT:INPUT"Want to change any";AN$
3620 TEST$=LEFT$(AN$,1)
3630 IF TEST$="N" OR TEST$="n" GOTO 3990
3640 IF TEST$="Y" OR TEST$="y" GOTO 3670
3650 PRINT:PRINT"Expected yes or no, re-enter."
3660 GOTO 3610
3670 PRINT:INPUT"Enter the line # to be changed";NLINE
3680 IF NLINE>=1 AND NLINE<=7 GOTO 3710
```

```
3690 PRINT:PRINT"Expected a number between 1 and 7, re-enter."
3700 GOTO 3670
3710 ON NLINE GOTO 3720,3740,3760,3780,3860,3950,3970
3720 PRINT:INPUT"Enter the spill size, barrels";BBL
3730 GOTO 3450
3740 PRINT:INPUT"Enter the duration for weathering, hours";X2
3750 GOTO 3450
3760 PRINT:INPUT"Enter the wind file name";WPFYL$
3770 GOTO 3450
3780 PRINT:INPUT"Want the slick to spread";AN$
3790 NSR=1
3800 TEST$=LEFT$(AN$,1)
3810 IF TEST$="Y" OR TEST$="y" GOTO 3450
3820 NSR=2
3830 PRINT:PRINT"Since the slick does not spread, enter a thickness";
3840 INPUT" in cm";Z
3850 GOTO 3450
3860 PRINT:INPUT"Want weathering to occur with dispersion";AN$
3870 NDR=1
3880 TEST$=LEFT$(AN$,1)
3890 IF TEST$="Y" OR TEST$="y" GOTO 3450
3900 IF TEST$="N" OR TEST$="n" GOTO 3930
3910 PRINT:PRINT"Expected yes or no, re-enter."
3920 GOTO 3860
3930 NDR=2
3940 GOTO 3450
3950 PRINT:INPUT"Enter the dispersion rate constant, 1/hr";AK
3960 GOTO 3450
3970 PRINT:INPUT"Enter the dispersion property constant";BK
3980 GOTO 3450
3990 REM NOW CALCULATE THE REST OF THE OIL WEATHERING INPUT PARAMETERS
4000 GOSUB 7790
4010 REM This section of the code asks for start, stop and loopback
4020 REM indices for use in the wind file.
4030 CLS
4040 PRINT:PRINT"You should have a copy of the wind-speed file, if not,";
4050 PRINT" get one"
4060 PRINT"by using WSPRINT.BAS"
4070 PRINT:INPUT"Enter the starting wind-speed entry # you want to use";IWS1
4080 PRINT:INPUT"Enter the last wind-speed entry # you want to use";IWS2
4090 PRINT:INPUT"Enter the loop-back entry #";IWS3
4100 PRINT:PRINT"1. The starting wind-speed entry # is > ";IWS1
4110 PRINT"2. The last wind-speed entry # is >>>>> ";IWS2
4120 PRINT"3. The loop-back entry # is >>>>>>>>>>> ";IWS3
4130 PRINT:INPUT"Are these ok and do they really fit in the specified file";AN$
4140 TEST$=LEFT$(AN$,1)
4150 IF TEST$="Y" OR TEST$="y" GOTO 4300
4160 IF TEST$="N" OR TEST$="n" GOTO 4190
4170 PRINT:PRINT"Expected yes or no, re-enter."
4180 GOTO 4130
4190 PRINT:INPUT"Which line number do you want to change";LCHANGE
4200 IF LCHANGE>=1 AND LCHANGE<=3 GOTO 4230
```

```
4210 PRINT:PRINT"Expected a number between 1 and 3, re-enter."
4220 GOTO 4190
4230 ON LCHANGE GOTO 4240,4260,4280
4240 PRINT:INPUT"Enter the new starting wind-speed entry #";IWS1
4250 GOTO 4100
4260 PRINT:INPUT"Enter the (new) last wind-speed entry #";IWS2
4270 GOTO 4100
4280 PRINT:INPUT"Enter the loop-back entry #";IWS3
4290 GOTO 4100
4300 REM Read in the specified wind speed file and create the one that
4310 REM the oil-weathering routine uses. This use file is a table
4320 REM consisting of an identification string, then on the next
4330 REM line ISTOP and LBACK, then the table entries which are
4340 REM wind speed in meters/second and duration in hours.
4350 OPEN "I",#1,WPFYL$
4360 INPUT #1, WSID$
4370 INPUT #1, INDEX1
4380 INDEX1=INDEX1-1
4390 FOR I - 1 TO INDEX1
4400 INPUT #1, WS1(I),HOURS1(I)
4410 NEXT I
4420 CLOSE #1
4430 ISTOP=IWS2-IWS1+1
4440 LBACK=IWS3-IWS1+1
4450 OPEN "O",#1,"ZYXWIND.ASC"
4460 PRINT #1, WPFYL$
4470 PRINT #1, IWS1,IWS2,IWS3
4480 PRINT #1, WSID$
4490 PRINT #1, ISTOP,LBACK
4500 FOR I - 1 TO ISTOP
4510 IDX-I+IWS1-1
4520 PRINT #1, WS1(IDX),HOURS1(IDX)
4530 NEXT I
4540 CLOSE #1
4550 ON NSR GOTO 4590,4560
4560 SPREAD=0!
4570 Z=Z/100!
4580 GOTO 4610
4590 SPREAD=1!
4600 Z=.02
4610 VOLUM=0!
4620 FOR I - 1 TO NCUTS
4630 VOLUM=VOLUM+AMOLES(I)/RHO(I)
4640 NEXT I
4650 VOLUMB=VOLUM/.159
4660 AREA=VOLUM/Z
4670 DIA=SQR(AREA/.785)
4680 TEMP=(.000082)*TK
4690 REM The variable TERM1 was multiplied by the wind speed in meters
4700 REM per hour raised to the 0.78 power in the constant-wind speed
4710 REM version of the oil-weathering model.
4720 TERM1=.015
```

```
4730 IF SPREAD=0 GOTO 4760
4740 TERM2=DIA^(-.11)
4750 GOTO 4770
4760 TERM2=.65
4770 AKH=TERM1*TERM2
4780 FOR I = 1 TO NC1
4790 AMTCA(I)=AKH*.93*SQR((AMW(I)+29!)/AMW(I))
4800 AMTC(I)=AMTCA(I)/TEMP
4810 NEXT I
4820 SPGRB=141.5/(APIB+131.5)
4830 AMASS=.1582*BBL*SPGRB
4840 REM The viscosity is scaled from the viscosity-reporting temperature
4850 REM to the weathering temperature.
4860 REM In the old code the reporting temperature was always 298 and
4870 REM 1/298 = 0.0033557
4880 VISCTERM=1!/(VISZT+273!)
4890 VSLEAD=VISZ*EXP(VK3*(1!/TK-VISCTERM))
4900 ON NDR GOTO 4950,4910
4910 FRACTS=0!
4920 GOTO 4960
4930 REM The following term must also be wind dependent, the function
4940 REM is AK*(1+WINDMS)^2
4950 FRACTS=AK
4960 XP=1
4970 X1=0!
4980 NCUTS1=NCUTS+1
4990 AMOLES(NCUTS1)=AREA
5000 IF C2>0! GOTO 5030
5010 C2R=0!
5020 GOTO 5040
5030 C2R=1!/C2
5040 REM NOW WRITE AN INTERMEDIATE DISK FILE FOR INPUT TO THE .EXE ROUTINE,
5050 REM WRITE THE BRKG4 CALLING ARGUMENTS AND COMMON BLOCKS.
5060 OPEN "O", #1, "ZYXWVU.ASC"
5070 PRINT #1, NCUTS,TME$
5080 PRINT #1, DTE$
5090 PRINT #1, X1,X2,XP,FRACTS,STEN,BK
5100 PRINT #1, Z,TERM2,SPREAD,C1,C2R
5110 PRINT #1, C4,AREA,VSLEAD,VK4
5120 FOR I = 1 TO NCUTS
5130 PRINT #1, AMOLES(I),AMTC(I),VP(I),RHO(I),AMW(I),SPGR(I)
5140 NEXT I
5150 CLOSE #1
5160 REM WRITE THE OIL-CHARACTERIZATION DATA TO A DISK FILE IF IT WAS
5170 REM ENTERED BY HAND
5180 REM IF IZ=2, SAVE IT FOR SURE
5190 REM IF NEDIT=1, ASK IF IT IS TO BE SAVED
5200 IF IZ=2 GOTO 5250
5210 IF NEDIT=0 GOTO 5600
5220 PRINT:INPUT"SINCE THE INPUT FILE WAS EDITED, WANT TO SAVE IT";AN$
5230 TEST$=LEFT$(AN$,1)
5240 IF TEST$="N" GOTO 5600
```

```
5250 PRINT:PRINT"Enter a NEW File Name to store this oil-characterization";
5260 PRINT" data";
5270 INPUT PFYL2$
5280 OPEN "O", #1, PFYL2$
5290 PRINT #1, MWSCTH
5300 PRINT #1, CNAME$
5310 PRINT #1, USING"##";NCUTS
5320 FOR I - 1 TO NCUTS
5330 PRINT #1, USING"####";TB(I);
5340 PRINT #1,",";
5350 PRINT #1, USING"###.#";API(I);
5360 PRINT #1,",";
5370 PRINT #1, USING"###.#";VOL(I);
5380 NEXT I
5390 REM START A NEW LINE
5400 REM The viscosity term below must be stored at a reporting temperture
5410 REM of 25 Deg C. (77 Deg F.), note that 1/298 - 0.003357
5420 IF VISZT=25! GOTO 5440
5430 VISZ-VISZ*EXP(VK3*(.0033557-1!/(VISZT+298!)))
5440 PRINT #1, USING"###.#";APIB;
5450 PRINT #1,",";
5460 PRINT #1, USING"##.##^^^^";VISZ;
5470 PRINT #1,",";
5480 PRINT #1, USING"##.##^^^^";VK3;
5490 PRINT #1,",";
5500 PRINT #1, USING"##.##^^^^";VK4
5510 REM START A NEW LINE
5520 PRINT #1, USING"#.##";C2;
5530 PRINT #1,",";
5540 PRINT #1, USING"#.##";C1;
5550 PRINT #1,",";
5560 PRINT #1, USING"##.##^^^^";C4;
5570 PRINT #1,",";
5580 PRINT #1, USING"###.#";STEN
5590 CLOSE #1
5600 REM NOW WRITE THE OIL-CHARACTERIZATION OUTPUT (CALCULATED RESULTS)
5610 REM TO THE DISK.  THIS FILE IS TO BE PRINTED AS THE 80-COLUMN OUTPUT
5620 REM FILE BY PRT80A.BAS
5625 PRINT
5630 INPUT"Enter a file name for the characterization output file";PFYL3$
5640 OPEN "O", #1, PFYL3$
5650 PRINT #1, MWSCTH,TME$
5660 PRINT #1, DTE$
5670 PRINT #1, CNAME$
5680 PRINT #1, CODEN$
5690 PRINT #1, USING"##";NCUTS
5700 FOR I - 1 TO NCUTS
5710 GMS-AMOLES(I)*MW(I)
5720 IMW-MW(I)
5730 PRINT #1, USING"##.##^^^^";AMOLES(I);
5740 PRINT #1,",";
5750 PRINT #1, USING"##.##^^^^";GMS;
```

```
5760 PRINT #1,",";
5770 PRINT #1, USING"##.##^^^^";VP(I);
5780 PRINT #1,",";
5790 PRINT #1, USING"##.##^^^^";TB(I);
5800 PRINT #1,",";
5810 PRINT #1, USING"##.##^^^^";API(I);
5820 PRINT #1,",";
5830 PRINT #1, USING"####";IMW
5840 NEXT I
5850 REM START A NEW LINE
5860 PRINT #1, USING"###.#";APIB;
5870 PRINT #1,",";
5880 PRINT #1, USING"##.##^^^^";VISZ;
5890 PRINT #1,",";
5900 PRINT #1, USING"##.##^^^^";VK3;
5910 PRINT #1,",";
5920 PRINT #1, USING"##.##^^^^";VK4
5930 REM START A NEW LINE
5940 PRINT #1, USING"#.##";C2;
5950 PRINT #1,",";
5960 PRINT #1, USING"#.##";C1;
5970 PRINT #1,",";
5980 PRINT #1, USING"##.##^^^^";C4;
5990 PRINT #1,",";
6000 PRINT #1, USING"###.#";STEN
6010 REM START A NEW LINE
6020 PRINT #1, USING"##.##^^^^";BBL;
6030 PRINT #1,",";
6040 PRINT #1, USING"###.#";WTMOLE;
6050 PRINT #1,",";
6060 PRINT #1, USING"##.#";DEGF
6070 REM START A NEW LINE
6080 PRINT #1, USING"##.##^^^^";AK;
6090 PRINT #1,",";
6100 PRINT #1, USING"##.##^^^^";BK
6110 CLOSE #1
6111 REM This is the end of the code.
6770 END
6780 REM THIS SUBROUTINE CHARACTERIZES A CUT OF CRUDE OIL WITH RESPECT
6790 REM TO VAPOR PRESSURE.  THE INPUT REQUIRED IS API GRAVITY AND THE
6800 REM BOILING POINT AT 1 ATMOSPHERE.  THE OUTPUT IS A SWITCH NS
6810 REM WHERE NS=1 MEANS THE VAPOR PRESSURE EQUATION CAN BE USED DOWN TO
6820 REM 10 MMHG AND NS=2 MEANS THE CLAPERYON EQUATION SHOULD BE USED.
6830 REM
6840 REM THE VAPOR PRESSURE EQUATION IS:
6850 REM
6860 REM LOG10(PR) = -A*(1.-TR)/TR - EXP(-20*(TR-B)^2)
6870 REM
6880 REM WHERE PR = REDUCED PRESSURE, TR = REDUCED TEMPERATURE AND
6890 REM A AND B ARE RETURNED BY THIS SUBROUTINE.
6900 REM
6910 REM API = GRAVITY, TB = BOILING POINT AT 1 ATMOSPHERE IN DEG F.
```

```
6920 REM NOW CALCULATE CRITICAL TEMPERATURE AND MOLECULAR WEIGHT.
6930 REM
6940 API2=APIN*APIN
6950 TB2=TBIN*TBIN
6960 CROSS=APIN*TBIN
6970 ON NV GOTO 6980,7240
6980 IY=1
6990 IF TBIN>500! THEN IY=2
7000 MW1=CZ(IY,1)+CZ(IY,2)*TBIN+CZ(IY,3)*APIN+CZ(IY,4)*CROSS+CZ(IY,5)*TB2
7010 MW1=MW1+CZ(IY,6)*API2
7020 TC1=TZ(IY,1)+TZ(IY,2)*TBIN+TZ(IY,3)*APIN+TZ(IY,4)*CROSS+TZ(IY,5)*TB2
7030 TC1=TC1+TZ(IY,6)*API2
7040 TCK=(TC1+459!)/1.8
7050 REM CALCULATE THE CARBON NUMBER
7060 CNUM1=(MW1-2!)/14!
7070 X=SCAL*LOG(CNUM1)
7080 REM CALCULATE B FOR THE VAPOR PRESSURE EQUATION
7090 BPRIME=PZ(1)+X*(PZ(2)+X*(PZ(3)+X*PZ(4)))
7100 BN=BPRIME-.02
7110 REM CALCULATE THE CRITICAL VOLUME, CC/MOLE
7120 VW=1.88+2.44*CNUM1
7130 VC1=VW/.044
7140 REM CALCULATE THE CRITICAL PRESSURE IN ATMOSPHERES
7150 PCP=20.8*TCK/(VC1-8!)
7160 PC1=PCP+10!
7170 TR=(TBIN+459!)/(TC1+459!)
7180 PR=1!/PC1
7190 NSN=1
7200 IF TR<BN GOTO 7230
7210 AN=(SCAL*LOG(PR)+EXP(-20!*(TR-BN)^2))*TR/(TR-1!)
7220 GOTO 7240
7230 NSN=2
7240 RETURN
7250 REM THIS SUBROUTINE EDITS AND THEN VOLUME NORMALIZES THE TBP INPUT DATA
7260 REM DISPLAY THE DATA
7270 PRINT:PRINT"Cut #      Boiling point     API     Vol %"
7280 FOR I=1 TO NCUTS
7290 PRINT USING"###";I;
7300 PRINT"          ";
7310 PRINT USING"###";TB(I);
7320 PRINT"           ";
7330 PRINT USING"##.#";API(I);
7340 PRINT"       ";
7350 PRINT USING"##.#";VOL(I)
7360 NEXT I
7370 PRINT:INPUT"Want to change any";ANS$
7380 TEST$=LEFT$(AN$,1)
7390 IF TEST$="N" OR TEST$="n" GOTO 7560
7400 IF TEST$="Y" OR TEST$="y" GOTO 7430
7410 PRINT:PRINT"Expected yes or no, re-enter."
7420 GOTO 7370
7430 PRINT:INPUT"Enter the cut # to be changed";J
```

```
7440 PRINT:PRINT"Enter 1 to change boiling point, 2 to change API, 3 to";
7450 INPUT" change Vol %";K
7460 IF K=1 OR K=2 OR K=3 GOTO 7490
7470 PRINT:PRINT"Expect 1, 2 or 3 to be entered, re-enter."
7480 GOTO 7430
7490 ON K GOTO 7500,7520,7540
7500 PRINT:INPUT"Enter the new boiling point in deg F";TB(J)
7510 GOTO 7270
7520 PRINT:INPUT"Enter the new API";API(J)
7530 GOTO 7270
7540 PRINT:INPUT"Enter the new Vol %";VOL(J)
7550 GOTO 7270
7560 REM RENORMALIZED THE VOLUME %
7570 VTOT=0!
7580 FOR I=1 TO NCUTS
7590 VTOT=VTOT+VOL(I)
7600 NEXT I
7610 FOR I=1 TO NCUTS
7620 VOL(I)=100!*VOL(I)/VTOT
7630 NEXT I
7640 REM Now check to see that the boiling points increase, if not,
7650 REM correct them from 40-mm Hg to 760-mm Hg.
7660 FOR I = 2 TO NCUTS
7670 IF TB(I)<TB(I-1) GOTO 7710
7680 NEXT I
7690 REM If an exit occurs from this for-next loop, no correction is required.
7700 GOTO 7780
7710 REM This is the 40-mm Hg to 760-mm Hg correction, on 10-9-91.
7720 IBOIL=I
7730 FOR I = IBOIL TO NCUTS
7740 REM Check for the 850 degrees F residuum fraction, do not scale it!
7750 IF TB(I)=850! GOTO 7770
7760 TB(I)=142.69+TB(I)*(1.1077+TB(I)*.0000519)
7770 NEXT I
7780 RETURN
7790 REM THIS SUBROUTINE CALCULATES INITIAL GRAM MOLES FOR EACH CUT AN
7800 REM A MEAN MOLE WEIGHT
7810 BM=.159*BBL
7820 TMOLES=0!
7830 FOR I = 1 TO NCUTS
7840 AMASS=1582!*SPGR(I)*BBL*VOL(I)
7850 AMOLES(I)=AMASS/MW(I)
7860 TMOLES=TMOLES+AMOLES(I)
7870 REM RHO IS THE DENSITY IN GM MOLES/CUBIC METER
7880 RHO(I)=100!*AMOLES(I)/(BM*VOL(I))
7890 NEXT I
7900 REM CALCULATE THE MEAN MOLE WEIGHT OF THE CRUDE
7910 WTMOLE=0!
7920 FOR I = 1 TO NCUTS
7930 WTMOLE=WTMOLE+MW(I)*AMOLES(I)/TMOLES
7940 NEXT I
7950 RETURN
```

```
7960 REM This subroutine allows the user to enter the viscosity in
7970 REM in centipoise or Saybolt Seconds.
7980 CLS
7990 PRINT:PRINT"Which viscosity units are to be entered, centipoise(C) or";
8000 INPUT" Saybolt Seconds(S)";AN$
8010 TESTV$=LEFT$(AN$,1)
8020 IF TESTV$="C" OR TESTV$="c" GOTO 8060
8030 IF TESTV$="S" OR TESTV$="s" GOTO 8080
8040 PRINT:PRINT"Expected centipoise or Saybolt Seconds, re-enter."
8050 GOTO 7990
8060 PRINT:INPUT"Enter the bulk viscosity, centipoise ";VISZ
8070 GOTO 8090
8080 PRINT:INPUT"Enter the bulk viscosity, Saybolt Seconds ";VISZ
8090 RETURN
```

APPENDIX B

OILWIND Source Code Listing

Appendix B: OILWIND Source Code Listing (Version of 1-31-92 @ 0759).

```
100 DEFINT I-N
110 DIM Y(20),AMTC(20),VP(18),RHO(18),AMW(18),SPGR(18),YSAVE(20),YARG(20)
120 DIM YMSAVE(20),AMWU(20),AK1(20),AK2(20),AK3(20),AK4(20),YF(20),YM(20)
130 DIM YM1(20),AK(20),TMPVP(20),TMPDS(20),WS1(340),HOURS1(340)
140 DEF FNWF(W)=(1!-C2*W)*EXP(-2.5*W/(1!-C1*W))
150 DEF FNXS(W)=EXP(2.5*W/(1!-C1*W))
160 WSAVE=-1!
165 C4SAVE=-1!
170 WCONTENT=0!
171 CODE$="OILWIND.BAS"
172 VER$="1-31-92 @ 0759"
180 CLS
181 PRINT TIME$
190 REM THIS IS THE MAIN OIL-WEATHERING CODE, CODE NAME IS OILWHER.BAS
200 REM READ IN THE INPUT DISK FILE TO GET GOING
210 OPEN "I", #1, "ZYXWVU.ASC"
220 INPUT #1, NEQ,TME$
230 INPUT #1, DTE$
240 INPUT #1, X1,X2,XP,FRACTS,STEN,AKB
250 INPUT #1, Z,TERM2,SPREAD,C1,C2
260 NEQ1=NEQ+1
270 INPUT #1, C4,Y(NEQ1),VSLEAD,VK4
280 FOR I = 1 TO NEQ
290 INPUT #1, Y(I),AMTC(I),VP(I),RHO(I),AMW(I),SPGR(I)
300 NEXT I
310 CLOSE #1
311 REM Note, the changes of September 3, 1991 are variable wind speed.
312 REM The mass transfer coefficient in AMTC(I) must now be multiplied
313 REM by the wind speed in meters/hour raised to the 0.78 power.  The
314 REM wind speed is read in in meters/second and the duration is in hours.
315 REM Also, FRACTS must be multiplied by (1+m/s)^2.
320 REM THE FIRST NCUTS=NEQ POSITIONS IN THE Y VECTOR ARE THE MOLES
330 REM OF THE COMPONENTS, POSITION NEQ+1 IS THE AREA OF THE SLICK,
340 REM POSITION NEQ+2 IS THE MASS LOST FROM THE SLICK BY DISPERSION
350 REM ALONE, POSITION NEQ+3 IS THE MASS LOST FROM THE SLICK BY
360 REM EVAPORATION ALONE.  NS IS A ROUTING SWITCH TO CHANGE THE PRINT
370 REM INTERVAL, IN IS AN INPUT ROUTING SWITCH TO DELETE THE RAPIDLY
380 REM CHANGING COMPONENTS.  GONE IS THE MASS FRACTION REMAINING AT A
390 REM TIME STEP.  ITN IS A SWITCH TO INDICATE WHEN THE INTEGRATION HAS
391 REM STARTED.  INT=1, NOT STARTED; INT=2, STARTED.
392 REM Read in the wind-speed information.
393 OPEN "I", #1, "ZYXWIND.ASC"
394 INPUT #1, WPFYL$
395 INPUT #1, IWS1,IWS2,IWS3
403 INPUT #1, WSID$
404 INPUT #1, ISTOPW, LBACKW
405 FOR I = 1 TO ISTOPW
406 INPUT #1, WS1(I),HOURS1(I)
407 NEXT I
408 CLOSE #1
```

```
410 REM This is the initial setup for the variable wind speed use.
411 REM Initialize the wind-index counter.
418 IWIND=1
419 WCHANGE=HOURS1(1)
420 WTERM1=(3600!*WS1(1))^.78
421 FOR I = 1 TO NEQ
422 AMTC(I)=AMTC(I)*WTERM1
423 NEXT I
424 WTERMF1=(1!+WS1(1))^2
425 FRACTS=FRACTS*WTERMF1
426 REM And finally calculate WINDS in knots for the mousse routine.
427 WINDS=1.944*WS1(1)
436 REM This is the end of the variable-wind initialization.
437 ITN=1
438 ITYP=1
439 NLINE=0
440 NEQ1=NEQ+1
450 NEQ2=NEQ+2
460 NEQ3=NEQ+3
470 NS=1
480 IN=1
490 IKEEP=1
500 GONE=1!
510 DISPER=0!
520 REM TOTAL IS THE INITIAL NUMBER OF MOLES, TSAVE IS THE INITIAL MASS
530 TOTAL=0!
540 TSAVE=0!
550 REM CALCULATE AND SAVE THE INITIAL CONDITIONS
560 FOR I = 1 TO NEQ
570 YSAVE(I)=Y(I)
580 YMSAVE(I)=Y(I)*AMW(I)
590 AMWU(I)=AMW(I)
600 TSAVE=TSAVE+YMSAVE(I)
610 TOTAL=TOTAL+Y(I)
620 NEXT I
630 REM SAVE THE INITIAL AREA
640 YMSAVE(NEQ1)=Y(NEQ1)
650 REM INITIALIZE THE MASS LOST BY DISPERSION ALONE AND EVAPORATION ALONE
660 Y(NEQ2)=0!
670 Y(NEQ3)=0!
680 REM NDEL IS THE NUMBER OF COMPONENTS DELETED BECAUSE THEY EVAPORATE
690 REM TOO FAST.  NFAST IS THE CURRENT ARRAY LOCATION OF THE FASTEST MOVING
700 REM COMPONENT.
710 NDEL=0
720 NFAST=0
730 X=X1
740 REM INITIALIZE THE PRINT SWITCH TO FORCE A PRINT AND SUBSEQUENT
750 REM CALCULATIONS THE FIRST TIME THROUGH.
760 XW=-1!
770 OPEN "O", #1, "OIL132.ASC"
780 PRINT #1, NEQ,TSAVE,TME$
790 PRINT #1, DTE$
```

```
800 FOR I=1 TO NEQ
810 PRINT #1, Y(I),YMSAVE(I)
820 NEXT I
830 REM CALCULATE DY/DX AND SET THE TIME STEP TO APPROXIMATE A 5% CHANGE
840 REM IN THE MOST RAPIDLY CHANGING Y.  WHEN THIS Y DECREASES BY A FACTOR
850 REM OF 20, RESET THE STEP SIZE ACCORDING TO THE NEXT Y.  SOME Y'S WILL
860 REM CHANGE SO FAST THAT THEY WILL BE GONE IN A FEW MINUTES.  THESE ARE
870 REM DELETED BEFORE INTEGRATION STARTS AND NOTED IN THE PRINTED RESULTS.
880 REM INITIALIZE THE INCREMENT NFAST.
890 NFAST=NFAST+1
900 REM CALCULATE THE DERIVATIVES.
910 ID=1
920 FOR I = 1 TO NEQ1
930 YARG(I)=Y(I)
940 NEXT I
950 GOSUB 3330
960 REM THE TIME UNIT IS HOUR.  SET THE STEP SIZE TO H=0.05*Y/(DY/DX)
970 H=.05*Y(NFAST)/AK1(NFAST)
980 YOLD=Y(NFAST)
990 H=ABS(H)
1000 H2=H/2!
1010 ON IN GOTO 1050,1430
1020 REM IF THERE IS A RAPIDLY MOVING COMPONENT AT THE BEGINNING, ITS
1030 REM STEP SIZE WILL BE VERY SMALL, DO NOT LET THE STEP SIZE BE LESS
1040 REM THAN 0.05 HOUR.
1050 IF H>.05 GOTO 1390
1060 REM Y(NFAST) CHANGES TOO FAST TO CALCULATE, DELETE IT AND MOVE
1070 REM EVERYBODY ONE SPACE TO THE LEFT.  WHEN YOU MOVE THE AREA BE
1080 REM SURE AND SUBTRACT THE CONTRIBUTION OF THE CUT JUST DELETED.
1090 ISTART=1
1100 NFAST=1
1110 NDEL=NDEL+1
1120 REM DECREASE THE NUMBER OF COMPONENTS BY 1
1130 NEQ=NEQ-1
1140 NEQ1=NEQ+1
1150 NEQ2=NEQ+2
1160 NEQ3=NEQ+3
1170 NEQ4=NEQ+4
1180 AD=Y(1)/RHO(1)/Z
1190 REM SHIFT THE ARRAYS
1200 FOR I = 1 TO NEQ
1210 I1=I+1
1220 Y(I)=Y(I1)
1230 VP(I)=VP(I1)
1240 AMTC(I)=AMTC(I1)
1250 YSAVE(I)=YSAVE(I1)
1260 RHO(I)=RHO(I1)
1270 AMWU(I)=AMWU(I1)
1280 YMSAVE(I)=YMSAVE(I1)
1290 NEXT I
1300 REM BE SURE AND DO THE LAST THREE POSITIONS WHEN SHIFTING
1310 Y(NEQ1)=Y(NEQ2)-AD
```

```
1320 Y(NEQ2)=Y(NEQ3)
1330 Y(NEQ3)=Y(NEQ4)
1340 REM THE ICODE PARAMETER TELLS THE PRINT ROUTINE WHAT IS TO BE READ NEXT.
1350 ICODE=1
1360 PRINT #1, ICODE
1370 PRINT #1, NDEL
1380 GOTO 910
1390 IN=2
1400 NEQ1=NEQ+1
1410 NEQ2=NEQ+2
1420 NEQ3=NEQ+3
1430 IF H>.5 THEN H=.5
1440 ICODE=2
1450 PRINT #1, ICODE
1460 PRINT #1, H,NFAST
1470 IF X<XW GOTO 2250
1480 REM PRINT INTERMEDIATE RESULTS.
1490 ICODE=3
1491 REM In order to get a good-looking print, check for the first time
1492 REM through when XW = -1; reset XW to 0.
1493 IF XW = -1 THEN XW = 0
1500 XW=XW+XP
1510 YTOT=0!
1520 TMASS=0!
1530 FOR I = 1 TO NEQ
1540 YF(I)=Y(I)/YSAVE(I)
1550 YTOT=YTOT+Y(I)
1560 YM(I)=Y(I)*AMWU(I)
1570 YM1(I)=YM(I)
1580 TMASS=TMASS+YM(I)
1590 YM(I)=YM(I)/YMSAVE(I)
1600 NEXT I
1610 YM1(NEQ1)=Y(NEQ1)
1620 REM CALCULATE THE MEAN MOLE WEIGHT OF THE OIL REMAINING IN THE SLICK.
1630 WMEANS=0!
1640 FOR I = 1 TO NEQ
1650 WMEANS=WMEANS+AMWU(I)*Y(I)/YTOT
1660 NEXT I
1670 PRINT #1, ICODE
1680 PRINT #1, X,NEQ
1690 PRINT"TIME = ";
1691 PRINT USING"###.#";X;
1700 PRINT", MASS FRACTION REMAINING=";
1701 PRINT USING"##.###";GONE
1710 FOR I = 1 TO NEQ
1720 PRINT #1, YM(I),YM1(I)
1730 NEXT I
1740 CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
1750 PRINT #1, TMASS,Y(NEQ2),Y(NEQ3),CHECK,WS1(IWIND)
1760 REM WHEN THE FRACTION REMAINING OF COMPONENT I GETS LOW, SET ITS VAPOR
1770 REM PRESSURE AND MOLES EQUAL TO ZERO.
1780 FOR I = ISTART TO NEQ
```

```
1790 IF YF(I)>1E-08 GOTO 1830
1800 IKEEP=I+1
1810 VP(I)=0!
1820 Y(I)=0!
1830 NEXT I
1840 ISTART=IKEEP
1850 NFAST=IKEEP
1860 GONE=TMASS/TSAVE
1870 ZP=Z*100!
1880 PRINT #1, GONE,Y(NEQ1),ZP,WMEANS
1890 REM CALCULATE THE MOUSSE
1900 GOSUB 3730
1910 REM VISCP1 IS THE VISCOSITY OF THE PARENT OIL WITH NO WATER INCORPORATED.
1920 REM VISCP1 IS IN CENTIPOISE, FEVAP IS THE FRACTION OF OIL EVAPORATED.
1930 REM NOTE THAT FEVAP IS NOT 1-(FRACTION REMAINING) BECAUSE DISPERSION
1940 REM LOSSES WOULD BE INCLUDED.  THE FRACTION EVAPORATED MUST BE CORRECTED
1950 REM FOR THE LOSS DUE TO DISPERSION.
1960 FEVAP=1!-GONE
1970 FEVAP=FEVAP/YM(NEQ)
1980 VISCP1=VSLEAD*EXP(VK4*FEVAP)
1990 REM VTERM IS THE VISCOSITY MULTIPLIER RETURNED FROM THE MOUSSE ROUTINE.
2000 VISCP=VISCP1*VTERM
2010 REM CALCULATE THE BULK SPGR.
2020 BSPGR=0!
2030 FOR I = ISTART TO NEQ
2040 BSPGR=BSPGR+SPGR(I)*Y(I)/YTOT
2050 NEXT I
2060 VISQT=SQR(VISCP/10!)
2070 REM CALCULATE THE DISPERSION FACTOR.
2080 FB=1!/(1!+AKB*VISQT*Z*STEN/.024)
2090 DISPER=FRACTS*FB
2100 PRINT #1, W,VISCP,DISPER
2110 CVOLUM=Y(NEQ1)*Z
2120 TBBL=CVOLUM/.159
2130 CVOLUM=(1000000!)*CVOLUM
2140 CSPGR=TMASS/CVOLUM
2150 WAREA=(1000000!)*Z*CSPGR
2160 WDISP=WAREA*DISPER
2170 IF ITN=1 THEN ERATE=0
2180 ERATE=ERATE/Y(NEQ1)
2190 PRINT #1, WAREA,CSPGR,TBBL,WDISP,ERATE
2200 ON NS GOTO 2210,2250
2210 IF X<50 GOTO 2250
2220 NS=2
2230 XP=10!
2240 REM TAKE A STEP.
2250 XARG=X
2260 FOR I = 1 TO NEQ3
2270 YARG(I)=Y(I)
2280 NEXT I
2290 REM ITN IS SET TO 2 TO INDICATE THE INTEGRATION WAS STARTED.
2300 ITN=2
```

```
2310 ID=1
2320 GOSUB 3330
2330 XARG=X+H2
2340 FOR I - 1 TO NEQ3
2350 YARG(I)=Y(I)+H*AK1(I)/2!
2360 NEXT I
2370 ERATE=AK1(NEQ3)
2380 ID=2
2390 GOSUB 3330
2400 FOR I - 1 TO NEQ3
2410 YARG(I)=Y(I)+H*AK2(I)/2!
2420 NEXT I
2430 ID=3
2440 GOSUB 3330
2450 XARG=X+H
2460 FOR I - 1 TO NEQ3
2470 YARG(I)=Y(I)+H*AK3(I)
2480 NEXT I
2490 ID=4
2500 GOSUB 3330
2510 FOR I - 1 TO NEQ3
2520 Y(I)=Y(I)+H*(AK1(I)+2!*(AK2(I)+AK3(I))+AK4(I))/6!
2530 NEXT I
2540 REM IF 10% BY MOLES OR LESS OF THE SLICK IS LEFT, STOP THE CALCULATION
2550 REM BECAUSE STRANGE THINGS HAPPEN CLOSE TO ZERO.
2560 REMAIN=0!
2570 FOR I - 1 TO NEQ
2580 REMAIN=REMAIN+Y(I)
2590 NEXT I
2600 TEST=REMAIN/TOTAL
2610 IF TEST>.1 GOTO 2640
2620 REM TOTAL MOLES IS LESS THAN 10%, STOP
2630 GOTO 3080
2640 REM RECALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENTS OUTSIDE
2650 REM THE DERIVATIVE SUBROUTINE.  THE DIAMETER DEPENDENCE IS VERY
2660 REM SLOW.  TERM2 IS THE OLD DIA^(-0.11).  SO DIVIDE THE OLD
2670 REM COEFFICIENT BY TERM2 AND MULTIPLY IN THE NEW ONE.
2680 REM WHEN YOU CHANGE THE WIND SPEED WITH RESPECT TO TIME,
2690 REM CHANGE THE MASS-TRANSFER COEFFICIENT HERE.  DIVIDE
2700 REM OUT THE OLD WIND TERM AND MULTIPLY IN THE NEW ONE.
2710 REM ALSO, IF THE TEMPERATURE CHANGES, RECALCULATE THE
2720 REM VAPOR PRESSURE HERE.  THIS APPLIES ONLY TO MACKAY
2730 REM AND MATSUGU.
2740 DIA=SQR(Y(NEQ1)/.785)
2750 TNEW=DIA^(-.11)
2760 ADJUST=TNEW/TERM2
2770 FOR I - 1 TO NEQ
2780 AMTC(I)=AMTC(I)*ADJUST
2790 NEXT I
2800 TERM2=TNEW
2810 REM This is the variable-wind speed addition of September 3, 1991.
2820 IF WCHANGE>XARG GOTO 2970
```

```
2830 IWIND=IWIND+1
2840 REM Check to see if the end of the table has been exceeded.
2850 IF IWIND<=ISTOPW GOTO 2880
2860 REM Reset IWIND to the loop-back index.
2870 IWIND=LBACKW
2880 WCHANGE=WCHANGE+HOURS1(IWIND)
2881 REM Calculate the new wind-speed mass-transfer term.
2890 WTERM2=(3600!*WS1(IWIND))^.78
2891 REM Multiply in the new and divide out the old.
2900 FOR I = 1 TO NEQ
2910 AMTC(I)=AMTC(I)*WTERM2/WTERM1
2920 NEXT I
2921 REM Now the new becomes the old.
2930 WTERM1=WTERM2
2931 REM Calculate the new wind-speed dispersion term.
2940 WTERMF2=(1!+WS1(IWIND))^2
2941 REM Multiply in the new and divide out the old.
2950 FRACTS=FRACTS*WTERMF2/WTERMF1
2951 REM Now the new becomes the old.
2960 WTERMF1=WTERMF2
2961 REM And finally calculate WINDS in knots for the mousse routine.
2962 WINDS=1.944*WS1(IWIND)
2970 REM CHECK TO SEE IF THE INTEGRATION IS COMPLETE.
2980 IF X>X2 GOTO 3080
2990 X=XARG
3000 REM CHECK TO SEE IF THE FIRST NON-ZERO MOLES HAS FALLEN TO
3010 REM 0.01 OF ITS STARTING VALUE.  IF IT HAS, RECALCULATE THE
3020 REM STEP SIZE ON THE NEXT NON-ZERO COMPONENT.  NOTE THAT
3030 REM A COMPONENT IS NOT ZEROED UNTIL ITS MOLE NUMBER HAS
3040 REM FALLEN TO LESS THAN 1.0E-08
3050 TEST=ABS(Y(NFAST)/YOLD)
3060 IF TEST<.01 GOTO 890
3070 GOTO 1470
3080 NDEL=NDEL+1
3090 REM BEGIN FINAL PRINT TO DISK
3100 ICODE=4
3110 TMASS=0!
3120 FOR I = 1 TO NEQ
3130 YM(I)=Y(I)*AMWU(I)
3140 TMASS=TMASS+YM(I)
3150 YM1(I)=YM(I)
3160 YM(I)=YM(I)/YMSAVE(I)
3170 NEXT I
3180 YM1(NEQ1)=Y(NEQ1)
3190 GONE=TMASS/TSAVE
3200 CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
3210 ZP=Z*100!
3220 PRINT #1, ICODE
3230 PRINT#1, NEQ,NDEL
3240 FOR I = 1 TO NEQ
3250 PRINT #1, YM(I),YM1(I)
3260 NEXT I
```

```
3270 PRINT #1, X,GONE,Y(NEQ1),ZP,WMEANS,TMASS
3280 PRINT #1, Y(NEQ2),Y(NEQ3),CHECK,WS1(IWIND)
3290 CLOSE #1
3300 PRINT:PRINT"WEATHERING CALCULATION DONE"
3310 PRINT TIME$
3320 END
3330 REM THIS IS THE DERIVATIVE SUBROUTINE
3340 REM THE VECTOR BEING INTEGRATED RESIDES IN YARG
3350 SUM=0!
3360 FOR I = 1 TO NEQ
3370 SUM=SUM+YARG(I)
3380 NEXT I
3390 FOR I = 1 TO NEQ
3400 REM CALCULATE THE MOLE DERIVATIVES
3410 TMPVP(I)=AMTC(I)*YARG(NEQ1)*VP(I)*YARG(I)/SUM
3420 TMPDS(I)=DISPER*YARG(I)
3430 AK(I)=TMPVP(I)+TMPDS(I)
3440 AK(I)=-AK(I)
3450 NEXT I
3460 VOLZ=0!
3470 FOR I = 1 TO NEQ
3480 VOLZ=VOLZ+YARG(I)/RHO(I)
3490 NEXT I
3500 REM CALCULATE THE AREA DERIVATIVE
3510 Z=VOLZ/YARG(NEQ1)
3520 AK(NEQ1)=(540000!)*(Z^1.33)*YARG(NEQ1)^.33
3530 AK(NEQ1)=SPREAD*AK(NEQ1)
3540 REM CALCULATE THE MASS LOST FROM THE SLICK DUE TO EVAPORATION ALONE
3550 REM AND THEN DISPERSION ALONE.
3560 AK(NEQ2)=0!
3570 AK(NEQ3)=0!
3580 FOR I  = 1 TO NEQ
3590 AK(NEQ3)=AK(NEQ3)+TMPVP(I)*AMWU(I)
3600 AK(NEQ2)=AK(NEQ2)+TMPDS(I)*AMWU(I)
3610 NEXT I
3620 FOR I = 1 TO NEQ3
3630 ON ID GOTO 3640,3660,3680,3700
3640 AK1(I)=AK(I)
3650 GOTO 3710
3660 AK2(I)=AK(I)
3670 GOTO 3710
3680 AK3(I)=AK(I)
3690 GOTO 3710
3700 AK4(I)=AK(I)
3710 NEXT I
3720 RETURN
3730 REM THIS IS THE WATER-IN-OIL (MOUSSE) SUBROUTINE
3740 REM W IS THE FRACTION WATER CONTENT IN THE OIL.
3750 REM WINDS IS THE WIND SPEED IN KNOTS.
3760 REM TIME IS IN HOURS AND IS THE VARIABLE X.
3770 REM C1 IS A VISCOSITY CONSTANT = 0.65
3780 REM C2 IS AN OIL-COALESCING CONSTANT AND IS OIL DEPENDENT, AND IS
```

```
3790 REM THE INVERSE OF THE MAXIMUM WEIGHT FRACTION WATER IN OIL.
3800 REM C3 IS A WATER INCORPORATION RATE (1/HR), USUALLY 0.001*U*U
3810 REM THE PREDICTION EQUATION FOR W IS IMPLICIT AND IS SOLVED BY
3820 REM TRIAL AND ERROR.
3830 REM REFERENCE: CHAPTER 4 BY MACKAY IN OIL SPILL PROCESSES AND MODELS.
3840 REM DECEMBER 1981
3850 REM IERR IS THE ERROR CODE.
3860 REM IERR=1 IS A NORMAL EXIT, IERR=2 IS A PROBLEM IN THE TRIAL-AND-ERROR
3870 REM ROUTINE, IERR=3 IS A STEADY-STATE MOUSSE EXIT.
3880 REM IF THE OIL DOES NOT FORM MOUSSE, C2 WAS SET TO -1.
3890 IF C2>0! GOTO 3990
3900 REM NO MOUSSE FOR THIS OIL, SET TERMS AND RETURN
3910 W=0!
3920 VTERM=1!
3930 GOTO 4290
3990 U2=WINDS*WINDS
4000 C3=C4*U2
4010 EX=C3*X
4020 IF EX>20! GOTO 4280
4030 TEST=EXP(-EX)
4040 REM BRACKET THE TIME WITH TWO VALUES OF W.
4050 W=0!
4060 WMAX=1!/C2
4070 WSTEP=WMAX/10!
4080 W=W+WSTEP
4090 TRY=FNWF(W)
4100 IF TRY<TEST GOTO 4150
4110 IF W<WMAX GOTO 4080
4120 IERR=2
4130 GOTO 4180
4140 REM NOW DO INTERVAL HALVING TO FIND W.
4150 NTRY=0
4160 WR=W
4170 WL=W-WSTEP
4180 W=(WR+WL)/2!
4190 TRY=FNWF(W)
4200 IF TRY<TEST GOTO 4230
4210 WL=W
4220 GOTO 4240
4230 WR=W
4240 NTRY=NTRY+1
4250 IF NTRY<10 GOTO 4180
4260 VTERM=FNXS(W)
4270 GOTO 4290
4280 IERR=3
4290 REM There is no known algorithm for the de-watering of a mousse
4291 REM when the wind decreases.  Everything works here for a steady
4292 REM or increasing wind speed.  Clearly, water can be "beat" into
4293 REM oil - and then on standing some of the water will come out.
4294 REM However, until such experiments are completed and an
4295 REM algorithm derived, the mousse in this code will ratchet
4296 REM itself.
```

```
4297 IF W < WCONTENT THEN W - WCONTENT
4298 WCONTENT - W
4299 RETURN
4300 END
```

APPENDIX C

PRTCHAR Source Code Listing

Appendix C: PRTCHAR Source Code Listing (Version of 2-11-92 @ 2111).

```
100 OPTION BASE 1
110 DEFINT I-N
120 REM THE FILE NAME IS PRTCHAR.BAS, JUNE 1985
130 REM THIS PRINT ROUTINE PRINTS THE OIL-CHARACTERIZATION 80-COLUMN
140 REM OUTPUT DISK FILE
150 DIM AMOLES(18),GMS(18),VP(18),TB(18),API(18),IMW(18)
160 TOF$=CHR$(12)
170 CPRT$="PRTCHAR.BAS"
171 VSION$="2-11-92 2111"
180 CLS
190 PRINT:INPUT"ENTER THE DISK FILE NAME TO BE PRINTED";PFYL3$
200 OPEN "I",#1,PFYL3$
210 INPUT #1, MWSCTH,TME$
220 INPUT #1, DTE$
230 INPUT #1, CNAME$
240 INPUT #1, CODEN$
250 INPUT #1, NCUTS
260 FOR I = 1 TO NCUTS
270 INPUT #1, AMOLES(I),GMS(I),VP(I),TB(I),API(I),IMW(I)
280 NEXT I
290 INPUT #1, APIB,VISZ,VK3,VK4
300 INPUT #1, C2,C1,C4,STEN
310 INPUT #1, BBL,WTMOLE,DEGF
320 INPUT #1, AK,BK
350 CLOSE #1
351 REM Read in the wind-speed table information for documentation
352 REM purposes.
353 OPEN "I",#1,"ZYXWIND.ASC"
354 INPUT #1, WPFYL$
355 INPUT #1, IWS1,IWS2,IWS3
356 CLOSE #1
360 LPRINT TOF$
370 LPRINT:LPRINT"OIL WEATHERING FOR: ";CNAME$
380 LPRINT:LPRINT"CODE NAME IS ";CODEN$;
390 LPRINT", PRINTED BY ";CPRT$
400 LPRINT:LPRINT"RUN TIME IS ";TME$;
410 LPRINT" HOURS ON ";DTE$
420 LPRINT:LPRINT"OIL VOLUME (SPILL), BARRELS = ";
430 LPRINT USING"##.##^^^^";BBL;
440 LPRINT", MEAN MOLE WEIGHT = ";
450 LPRINT USING"###";WTMOLE
460 LPRINT:LPRINT"TEMPERATURE, DEGREES F = ";
470 LPRINT USING"###";DEGF
480 LPRINT:LPRINT"THE WIND-SPEED TABLE CAME FROM THE FILE ";WPFYL$
500 LPRINT"THE STARTING WIND ENTRY USED IS > ";IWS1
510 LPRINT"THE ENDING WIND ENTRY USED IS >>> ";IWS2
520 LPRINT"THE LOOP BACK WIND ENTRY IS >>>>> ";IWS3
530 LPRINT:LPRINT"FOR THE OUTPUT THAT FOLLOWS, MOLES = GRAM MOLES"
540 LPRINT"GMS = GRAMS, VP = VAPOR PRESSURE IN ATMOSPHERES"
550 LPRINT"BP = BOILING POINT IN DEGREES F, API = GRAVITY"
```

```
560 LPRINT"MW - MOLECULAR WEIGHT"
570 LPRINT:LPRINT" CUT     MOLES       GMS        VP         BP         API";
580 LPRINT"         MW"
590 FOR I - 1 TO NCUTS
600 LPRINT"   ";
610 LPRINT USING"##";I;
620 LPRINT"   ";
630 LPRINT USING"##.##^^^^";AMOLES(I);
640 LPRINT" ";
650 LPRINT USING"##.##^^^^";GMS(I);
660 LPRINT" ";
670 LPRINT USING"##.##^^^^";VP(I);
680 LPRINT" ";
690 LPRINT USING"##.##^^^^";TB(I);
700 LPRINT" ";
710 LPRINT USING"##.##^^^^";API(I);
720 LPRINT" ";
730 LPRINT USING"##.##^^^^";IMW(I)
740 NEXT I
750 SPGRB=141.5/(APIB+131.5)
760 LPRINT:LPRINT"BULK API GRAVITY - ";
770 LPRINT USING"###.#";APIB;
780 LPRINT", SPGR = ";
790 LPRINT USING"#.###";SPGRB
800 LPRINT:LPRINT"BULK CRUDE VISCOSITY, CENTIPOISE - ";
810 LPRINT USING"##.##^^^^";VISZ
820 LPRINT:LPRINT"VISCOSITY CONSTANT FOR FRACTION-OIL-WEATHERED - ";
830 LPRINT USING"##.##^^^^";VK4
840 LPRINT:LPRINT"VISCOSITY-TEMPERATURE SCALING CONSTANT (ANDRADA) - ";
850 LPRINT USING"##.##^^^^";VK3
860 LPRINT:LPRINT"MAXIMUM FRACTION WATER IN OIL (MOUSSE) - ";
870 LPRINT USING"#.##";C2
880 LPRINT:LPRINT"MOUSSE-VISCOSITY CONSTANT - ";
890 LPRINT USING"#.##";C1
900 LPRINT:LPRINT"MOUSSE WATER-INCORPORATION RATE CONSTANT - ";
910 LPRINT USING"##.##^^^^";C4
920 LPRINT:LPRINT"OIL/WATER SURFACE TENSION, DYNES/CM - ";
930 LPRINT USING"###.#";STEN
940 LPRINT:LPRINT"DISPERSION CONSTANTS ARE: AK - ";
950 LPRINT USING"##.##^^^^";AK;
960 LPRINT", BK = ";
970 LPRINT USING"##.##^^^^";BK
980 LPRINT TOF$
990 END
```

APPENDIX D

PRTRSLT Source Code Listing

Appendix D: PRSRSLT Source Code Listing (Version of 9-26-92 @ 0828).

```
100 REM *****
110 REM CODE NAME IS PRTRSLT.BAS
120 DIM Y(20),YMSAVE(20),YM(20),YM1(20)
130 DIM T(200),MOUSSE(200),FEVAP(200),FDISP(200),IFIVE(200),IFIFTY(200)
140 DIM DEVAP(200),RMASS(200)
150 REM Since everything cannot be printed nicely on one page, save the
160 REM mousse composition, fraction evaporated, fraction dispersed,
170 REM the total mass, and the composition indicies for the
180 REM second-page print.
190 REM N is the save counter.
200 N=0
210 IDEL=0
220 IS=1
230 TOF$=CHR$(12)
240 REM Initialize the page counter.
250 IPAGE=1
260 REM Set the lines of data per page.
270 N36=36
280 REM Set the page counter switch.
290 PSWITCH=N36
300 CODEN$="PRTRSLT.BAS"
310 VRSON$="9-26-92 @ 0828"
320 OPEN "I", #1, "OIL132.ASC"
330 INPUT #1, NEQ,TSAVE,TME$
340 INPUT #1, DTE$
350 FOR I = 1 TO NEQ
360 INPUT #1, Y(I),YMSAVE(I)
370 NEXT I
380 REM FROM NOW ON READ AN INPUT CODE WHERE:
390 REM   ICODE = 1 MEANS NDEL IS TO BE READ NEXT,
400 REM   ICODE = 2 MEANS H,NFAST IS TO BE READ NEXT,
410 REM   ICODE = 3 MEANS X,
420 REM             YM(I),YM1(I)
430 REM             TMASS,Y(NEQ2),Y(NEQ3),CHECK,WINDS
440 REM             GONE,Y(NEQ1),ZP,WMEANS
450 REM             W,VISCP,DISPER
460 REM             WAREA,CSPGR,TBBL,WDISP,ERATE ARE TO BE READ NEXT, AND
470 REM   ICODE = 4 MEANS NEQ,NDEL
480 REM             YM(I),YM1(I)
490 REM             X,GONE,Y(NEQ1),ZP,WMEANS,TMASS
500 REM             Y(NEQ2),Y(NEQ3),CHECK,WINDS ARE TO BE READ NEXT.
510 REM   ICODE = 4 IS THE LAST READ.
520 REM Do an initial print.
530 GOSUB 1580
540 INPUT #1, ICODE
550 ON ICODE GOTO 560,590,610,1150
560 INPUT #1, NDEL
570 IDEL=IDEL+NDEL
580 GOTO 540
590 INPUT #1, H,NFAST
```

```
600 GOTO 540
610 INPUT #1, X,NEQ
620 FOR I=1 TO NEQ
630 INPUT #1, YM(I),YM1(I)
640 NEXT I
650 NEQ1=NEQ+1
660 NEQ2=NEQ+2
670 NEQ3=NEQ+3
680 INPUT #1, TMASS,Y(NEQ2),Y(NEQ3),CHECK,WINDS
690 INPUT #1, GONE,Y(NEQ1),ZP,WMEANS
700 INPUT #1, W,VISCP,DISPER
710 INPUT #1, WAREA,CSPGR,TBBL,WDISP,ERATE
720 LPRINT USING"####";X;
730 LPRINT"   ";
740 LPRINT USING"##.#";WINDS;
750 LPRINT"      ";
760 LPRINT USING"#.##";GONE;
770 LPRINT"      ";
780 LPRINT USING"#.##";CSPGR;
790 LPRINT" ";
800 LPRINT USING"##.#^^^^";Y(NEQ1);
810 LPRINT" ";
820 LPRINT USING"##.#^^^^";ZP;
830 LPRINT"   ";
840 LPRINT USING"###.#";WMEANS;
850 LPRINT"   ";
860 LPRINT USING"##.#^^^^";VISCP
870 REM Check the line counter, put 36 lines of data on one page, then
880 REM start over.
890 IF N<=PSWITCH GOTO 960
900 REM Increment the page counter.
910 IPAGE=IPAGE+1
920 REM Now print a page header.
930 GOSUB 1580
940 REM And increment the page switch to get ready for the next one.
950 PSWITCH=PSWITCH+N36
960 N=N+1
970 T(N)=X
980 MOUSSE(N)=W
990 FEVAP(N)=Y(NEQ3)/CHECK
1000 DEVAP(N)=Y(NEQ2)/CHECK
1010 REM Scale the mass remaining to metric tonnes.
1020 RMASS(N)=TMASS/1000000!
1030 FOR I=1 TO NEQ
1040 IF YM(I)>.05 GOTO 1060
1050 NEXT I
1060 FOR J=1 TO NEQ
1070 IF YM(J)>.5 GOTO 1090
1080 NEXT J
1090 I=I+IDEL
1100 J=J+IDEL
1110 IFIVE(N)=I
```

```
1120 IFIFTY(N)-J
1130 IF IS-2 GOTO 1280
1140 GOTO 540
1150 INPUT #1,NEQ,NDEL
1160 FOR I-1 TO NEQ
1170 INPUT #1, YM(I),YM1(I)
1180 NEXT I
1190 NEQ1-NEQ+1
1200 NEQ2-NEQ+2
1210 NEQ3-NEQ+3
1220 INPUT #1, X,GONE,Y(NEQ1),ZP,WMEANS,TMASS
1230 INPUT #1, Y(NEQ2),Y(NEQ3),CHECK,WINDS
1240 CLOSE #1
1250 IS-2
1260 REM Do not do a final print if the last two times are the same.
1270 IF X<>T(N) GOTO 720
1280 REM Start the second set of output.
1290 IPAGE-IPAGE+1
1300 REM Print the new header.
1310 GOSUB 1760
1320 REM Reset the page counter switch.
1330 PSWITCH=N36
1340 REM And start the print.
1350 FOR J - 1 TO N
1360 IF J<=PSWITCH GOTO 1430
1370 REM Increment the page counter.
1380 IPAGE-IPAGE+1
1390 REM Print the header.
1400 GOSUB 1760
1410 REM And increment the page switch to get ready for the next one.
1420 PSWITCH-PSWITCH+N36
1430 LPRINT USING"####";T(J);
1440 LPRINT"      ";
1450 LPRINT USING"#.##";MOUSSE(J);
1460 LPRINT"      ";
1470 LPRINT USING"##.##^^^^";RMASS(J);
1480 LPRINT"       ";
1490 LPRINT USING"#.##";FEVAP(J);
1500 LPRINT"       ";
1510 LPRINT USING"#.##";DEVAP(J);
1520 LPRINT"      ";
1530 LPRINT USING"##";IFIVE(J);
1540 LPRINT"      ";
1550 LPRINT USING"##";IFIFTY(J)
1560 NEXT J
1570 END
1580 REM This subroutine prints the header for the first set of output.
1590 LPRINT TOF$
1600 LPRINT:LPRINT"OIL WEATHERING OUTPUT AT ";TME$;
1610 LPRINT" HOURS ON ";DTE$;
1620 LPRINT",   Page ";
1630 LPRINT USING"##";IPAGE
```

```
1640 LPRINT:LPRINT"CODE NAME IS ";CODEN$
1650 LPRINT:LPRINT"FOR OUTPUT BELOW THE FOLLOWING NOTATION APPLIES"
1660 LPRINT:LPRINT"TIME IS HOURS"
1670 LPRINT"WIND IS THE WIND SPEED IN METERS/SECOND"
1680 LPRINT"FRACTION IS MASS FRACTION REMAINING IN THE SLICK"
1690 LPRINT"SPGR IS THE SPECIFIC GRAVITY"
1700 LPRINT"AREA IS THE SLICK AREA IN METER*METER
1710 LPRINT"THICKNESS IS THE SLICK THICKNESS IN CM"
1720 LPRINT"MOLE WT IS THE MEAN MOLECULAR WEIGHT OF THE SLICK"
1730 LPRINT"VISC IS THE VISCOSITY IN CP"
1740 LPRINT:LPRINT"TIME  WIND  FRACTION SPGR   AREA    THICK MOLE WT    VISC"
1750 RETURN
1760 REM This subroutine prints the header for the second set of output.
1770 LPRINT TOF$
1780 LPRINT:LPRINT"OIL WEATHERING OUTPUT AT ";TME$;
1790 LPRINT" HOURS ON ";DTE$;
1800 LPRINT",    Page ";
1810 LPRINT USING"##";IPAGE
1820 LPRINT:LPRINT"CODE NAME IS ";CODEN$
1830 LPRINT
1840 LPRINT"FOR THE OUTPUT BELOW THE FOLLOWING NOTATION APPLIES"
1850 LPRINT
1860 LPRINT"TIME IS HOURS"
1870 LPRINT"MOUSSE IS THE MASS FRACTION WATER IN THE OIL + WATER"
1880 LPRINT"TOTAL-MASS IS THE METRIC-TON MASS OF OIL IN THE SLICK"
1890 LPRINT"F-EVAP IS THE MASS FRACTION EVAPORATED INTO THE ATMOSPHERE"
1900 LPRINT"F-DISP IS THE MASS FRACTION DISPERSED INTO THE WATER COLUMN"
1910 LPRINT"I IS THE FIRST CUT WITH GREATER THAN  5%";
1911 LPRINT" OF INITIAL REMAINING"
1920 LPRINT"J IS THE FIRST CUT WITH GREATER THAN 50%";
1921 LPRINT" OF INITIAL REMAINING"
1930 LPRINT
1940 LPRINT:LPRINT"TIME   MOUSSE   TOTAL-MASS   F-EVAP   F-DISP   I    J"
1950 RETURN
```

APPENDIX E

WSPEED Source Code Listing

Appendix E: WSPEED Source Code Listing (Version of 1-28-92 @ 2143).

```
100 REM ******
110 REM This Basic code is used to create a wind-speed and time-duration
120 REM table or to edit an existing table.  Editing features include
130 REM deletion, insertion, change or adding on of wind-speed
140 REM and time-duration data pairs.
150 DIM WS(1000),HOURS(1000),ELAP(1000),C$(11)
160 C$(1)="1":C$(2)="2":C$(3)="3":C$(4)="4":C$(5)="5"
170 C$(6)="6":C$(7)="7":C$(8)="8":C$(9)="9":C$(10)="0"
180 C$(11)="."
190 CODE$="WSPEED.BAS"
200 VER$="1/28/92 @ 2143"
210 REM PFYL$ is a temporary file, do not use this name.
220 PFYLS$="WSRESULT.ASC"
230 REM PINC IS THE NUMBER OF ROWS OF INFORMATION DISPLAYED ON THE CRT.
240 PINC=10
250 CLS
260 PRINT:PRINT"This utility code creates and/or edits wind-speed and";
270 PRINT" time-duration tables"
280 PRINT"for use in the oil-weathering code."
290 PRINT:PRINT"Do you want to edit(E) an existing table or";
300 INPUT" start(S) a new one";AN$
310 TEST$=LEFT$(AN$,1)
320 IF TEST$="E" OR TEST$="e" GOTO 1420
330 IF TEST$="S" OR TEST$="s" GOTO 360
340 PRINT:PRINT"You should enter 'E' for edit or 'S' for start.
350 GOTO 290
360 CLS
370 REM THIS STARTS A NEW TABLE.
380 PRINT:INPUT"Enter an identification string for this table";WSID$
390 REM ECHO AND ASK IF THIS IS OK.
400 PRINT:PRINT"You entered: ";WSID$
410 PRINT:INPUT"Is this ok";AN$
420 TEST$=LEFT$(AN$,1)
430 IF TEST$="Y" OR TEST$="y" GOTO 490
440 IF TEST$="N" OR TEST$="n" GOTO 470
450 PRINT:PRINT"Expected yes or no, re-enter."
460 GOTO 400
470 PRINT:PRINT"Ok, re-enter it."
480 GOTO 380
490 CLS
500 PRINT:INPUT"Are you entering knots(K), or meters(M) per second";AN$
510 TEST$=LEFT$(AN$,1)
520 SCODE=1
530 IF TEST$="M" OR TEST$="m" GOTO 600
540 REM This is the multiplicative scale factor to convert knots
550 REM to meters per second.
560 SCODE=.5144
570 IF TEST$="K" OR TEST$="k" GOTO 600
580 PRINT:PRINT"You did not enter K or M, so re-enter."
590 GOTO 490
```

```
600 INDEX=0
610 INDEX=INDEX+1
620 PRINT:INPUT"Enter a wind speed (or stop)";AN$
630 TEST$=LEFT$(AN$,1)
640 IF TEST$="S" OR TEST$="s" GOTO 1270
650 REM Now check to see that a keyboard finger-drag error has not occurred.
660 REM First get the length, or number of characters, in the input value.
670 L=LEN(AN$)
680 REM Now retrieve each character and check to see that it is a number
690 REM or a decimal point.
700 FOR I = 1 TO L
710 REM Retrieve the i-th character only.
720 V$=MID$(AN$,I,1)
730 REM Compare this character with the numbers stored as strings, and
740 REM also the decimal point.
750 FOR J = 1 TO 11
760 REM When a comparison is valid, it is ok, so loop out.
770 IF V$=C$(J) GOTO 980
780 NEXT J
790 REM At this point check to see if there is a minus or plus sign
800 REM out front.  This is ok but tell the user it is not necessary
810 REM and save them some time.
820 TEST$=LEFT$(AN$,1)
830 IF TEST$="+" GOTO 860
840 IF TEST$="-" GOTO 890
850 GOTO 920
860 BEEP
870 PRINT:PRINT"You do not have to enter the + sign."
880 GOTO 980
890 BEEP
900 PRINT:PRINT"Negative signs do not make sense for wind speed."
910 GOTO 960
920 REM Going all the way through this loop means something is wrong.
930 BEEP
940 PRINT:PRINT"It appears that the value entered is not a number,";
950 PRINT" it is: ";AN$
960 PRINT:PRINT"So, re-enter this value."
970 GOTO 620
980 NEXT I
990 WS(INDEX)=VAL(AN$)
1000 PRINT:INPUT"Enter the duration, hours";HOURS(INDEX)
1010 IF HOURS(INDEX)>0! GOTO 1050
1020 BEEP
1030 PRINT:PRINT"You entered zero(0) for the duration, so re-enter."
1040 GOTO 1000
1050 ISTART=1
1060 ELAPSE=0!
1070 IF INDEX<PINC+1 GOTO 1140
1080 ISTART=INDEX-PINC+1
1090 REM CALCULATE THE ELAPSED TIME UP TO THE FIRST DISPLAY.
1100 ISTOP=ISTART-1
1110 FOR I = 1 TO ISTOP
```

```
1120 ELAPSE=ELAPSE+HOURS(I)
1130 NEXT I
1140 CLS
1150 PRINT:PRINT:PRINT"Row #      Speed      Duration      Elasped"
1160 FOR I = ISTART TO INDEX
1170 ELAPSE=ELAPSE+HOURS(I)
1180 PRINT USING"###";I;
1190 PRINT"       ";
1200 PRINT USING"###.#";WS(I);
1210 PRINT"        ";
1220 PRINT USING"###.#";HOURS(I);
1230 PRINT"         ";
1240 PRINT USING"###.#";ELAPSE
1250 NEXT I
1260 GOTO 610
1270 PRINT:PRINT"End of wind-speed data entry."
1280 PRINT:INPUT"Now enter a file name for saving these data";PFYL$
1290 REM TACK ON A ZERO FOR THE LAST WIND SPEED.
1300 WS(INDEX)=0
1310 HOURS(INDEX)=0
1320 OPEN "O",#1,PFYL$
1330 PRINT #1, WSID$
1340 PRINT #1,INDEX
1350 FOR I = 1 TO INDEX
1360 REM SCALE THE WIND SPEED TO METERS PER SECOND, IF NECESSARY.
1370 WS(I)=SCODE*WS(I)
1380 PRINT #1,WS(I),HOURS(I)
1390 NEXT I
1400 CLOSE #1
1410 END
1420 REM THIS IS THE START OF THE EDIT ROUTINE.
1430 PRINT:PRINT"Enter the file name (with the drive letter";
1440 INPUT" if necessary)";PFYL$
1450 OPEN "I", #1, PFYL$
1460 INPUT #1, WSID$
1470 INPUT #1,INDEX
1480 FOR I = 1 TO INDEX
1490 INPUT #1, WS(I),HOURS(I)
1500 NEXT I
1510 CLOSE #1
1520 INDEX=INDEX-1
1530 REM NOW DISPLAY THE FILE AND ASK FOR INSERTION OR DELETIONS.
1540 ELAPSE=0
1550 REM THE DISPLAY PRINT INCREMENT IS PINC.
1560 ELAP(1)=0
1570 FOR J = 1 TO 50
1580 KSTOP=PINC*J
1590 KSTART=KSTOP-PINC+1
1600 JOUT=1
1610 IF INDEX>KSTOP GOTO 1640
1620 KSTOP=INDEX
1630 JOUT=2
```

```
1640 ELAPSE=ELAP(J)
1650 CLS
1660 PRINT:PRINT"Row #    Knots    Duration    Elapsed"
1670 FOR K = KSTART TO KSTOP
1680 ELAPSE=ELAPSE+HOURS(K)
1690 PRINT USING"###";K;
1700 PRINT"      ";
1710 PRINT USING"###.#";WS(K);
1720 PRINT"      ";
1730 PRINT USING"###.#";HOURS(K);
1740 PRINT"        ";
1750 PRINT USING"###.#";ELAPSE
1760 NEXT K
1770 ELAP(J+1)=ELAPSE
1780 ON JOUT GOTO 1790,2000
1790 PRINT
1800 PRINT"Want to delete(D), insert(I), change(C), go(G) on";
1810 INPUT", or finish(f)";AN$
1820 TEST$=LEFT$(AN$,1)
1830 IF TEST$="D" OR TEST$="d" GOTO 1910
1840 IF TEST$="I" OR TEST$="i" GOTO 1940
1850 IF TEST$="G" OR TEST$="g" GOTO 2140
1860 IF TEST$="C" OR TEST$="c" GOTO 1970
1870 IF TEST$="F" OR TEST$="f" GOTO 2150
1880 PRINT:PRINT"You did not enter D, I, C, G or F, please re-enter."
1890 PRINT
1900 GOTO 1800
1910 REM THIS IS THE DELETE CALL.
1920 GOSUB 2410
1930 GOTO 1580
1940 REM THIS IS THE INSERT CALL.
1950 GOSUB 2580
1960 GOTO 1580
1970 REM THIS IS THE CHANGE CALL.
1980 GOSUB 3020
1990 GOTO 1580
2000 PRINT
2010 INPUT"Want to delete(D), insert(I), change(C), add(A) or finish(F)";AN$
2020 TEST$=LEFT$(AN$,1)
2030 IF TEST$="D" OR TEST$="d" GOTO 1910
2040 IF TEST$="I" OR TEST$="i" GOTO 1940
2050 IF TEST$="A" OR TEST$="a" GOTO 2110
2060 IF TEST$="F" OR TEST$="f" GOTO 2150
2070 IF TEST$="C" OR TEST$="c" GOTO 1970
2080 PRINT:PRINT"You did not enter D, I, C, A or F, please re-enter."
2090 PRINT
2100 GOTO 2010
2110 REM THIS IS THE ADD CALL.
2120 GOSUB 2830
2130 GOTO 1580
2140 NEXT J
2150 CLS
```

E-7

```
2160 PRINT:PRINT"The identification string is: ";WSID$
2170 PRINT:INPUT"Do you want to change it";AN$
2180 TEST$=LEFT$(AN$,1)
2190 IF TEST$="N" OR TEST$="n" GOTO 2250
2200 IF TEST$="Y" OR TEST$="y" GOTO 2230
2210 PRINT:PRINT"Expected yes or no, re-enter."
2220 GOTO 2160
2230 PRINT:INPUT"Enter the new identification string: ";WSID$
2240 GOTO 2160
2250 PRINT:PRINT"The edited file was saved as: ";PFYLS$;
2260 PRINT" on the default drive."
2270 PRINT:PRINT"Get back in DOS and rename it for your use."
2280 PRINT:PRINT"Also, print a hard copy of your file using WSPRINT.BAS"
2290 OPEN "O",#1,PFYLS$
2300 REM TACK ON THE 0,0 ENTERY
2310 INDEX=INDEX+1
2320 WS(INDEX)=0!
2330 HOURS(INDEX)=0!
2340 PRINT #1,WSID$
2350 PRINT #1,INDEX
2360 FOR I = 1 TO INDEX
2370 PRINT #1, WS(I),HOURS(I)
2380 NEXT I
2390 CLOSE #1
2400 END
2410 REM SUBROUTINE TO DELETE AN ENTRY.
2420 PRINT:INPUT"Enter the row number to be deleted";IDEL
2430 PRINT:PRINT"You entered ";IDEL
2440 PRINT:INPUT"Is this correct, it should be on the screen ";AN$
2450 TEST$=LEFT$(AN$,1)
2460 IF TEST$="Y" OR TEST$="y" GOTO 2520
2470 IF TEST$="N" OR TEST$="n" GOTO 2500
2480 PRINT:PRINT"Expected yes or no, re-enter."
2490 GOTO 2430
2500 PRINT:PRINT"Ok, re-enter it."
2510 GOTO 2420
2520 FOR ID=IDEL TO INDEX
2530 WS(ID)=WS(ID+1)
2540 HOURS(ID)=HOURS(ID+1)
2550 NEXT ID
2560 INDEX=INDEX-1
2570 RETURN
2580 REM SUBROUTINE TO INSERT AN ENTRY.
2590 PRINT:INPUT"Enter the row number that the insert follows";INS
2600 PRINT:PRINT"You entered";INS
2610 PRINT:INPUT"Is this correct, it should be on the screen ";AN$
2620 TEST$=LEFT$(AN$,1)
2630 IF TEST$="Y" OR TEST$="y" GOTO 2690
2640 IF TEST$="N" OR TEST$="n" GOTO 2670
2650 PRINT:PRINT"Expected yes or no, re-enter."
2660 GOTO 2600
2670 PRINT:PRINT"Ok, re-enter it."
```

```
2680 GOTO 2590
2690 PRINT:INPUT"Enter the insert wind speed, knots";WINS
2700 PRINT:INPUT"Enter the insert duration, hours";HINS
2710 INS=INS+1
2720 REM THIS LOOP MOVES THE TABLE ENTRIES DOWN BY ONE(1).
2730 JKOUNT=INDEX+1
2740 FOR ID = INS TO INDEX
2750 WS(JKOUNT)=WS(JKOUNT-1)
2760 HOURS(JKOUNT)=HOURS(JKOUNT-1)
2770 JKOUNT=JKOUNT-1
2780 NEXT ID
2790 WS(INS)=WINS
2800 HOURS(INS)=HINS
2810 INDEX=INDEX+1
2820 RETURN
2830 REM SUBROUTINE TO ADD SOME DATA PAIRS
2840 PRINT:INPUT"Enter the number of wind speeds to add";IADD
2850 PRINT:PRINT"You entered ";IADD
2860 PRINT:INPUT"Is this correct";AN$
2870 TEST$=LEFT$(AN$,1)
2880 IF TEST$="Y" OR TEST$="y" GOTO 2940
2890 IF TEST$="N" OR TEST$="n" GOTO 2920
2900 PRINT:PRINT"Expected yes or no, re-enter."
2910 GOTO 2850
2920 PRINT:PRINT"Ok, re-enter it."
2930 GOTO 2840
2940 FOR KL = 1 TO IADD
2950 INDEX=INDEX+1
2960 PRINT:PRINT"Enter the add-on wind speed";
2970 PRINT USING"##";KL;
2980 INPUT": ";WS(INDEX)
2990 PRINT:INPUT"Enter the next duration";HOURS(INDEX)
3000 NEXT KL
3010 RETURN
3020 REM SUBROUTINE TO CHANGE AN INPUT DATA PAIR
3030 PRINT:INPUT"Enter the row number to be changed ";LCHANGE
3040 PRINT:PRINT"You entered ";LCHANGE
3050 PRINT:INPUT"Is this correct, it should be on the screen  ";AN$
3060 TEST$=LEFT$(AN$,1)
3070 IF TEST$="Y" OR TEST$="y" GOTO 3130
3080 IF TEST$="N" OR TEST$="n" GOTO 3110
3090 PRINT:PRINT"Expected yes or no, re-enter."
3100 GOTO 3040
3110 PRINT:PRINT"Ok, re-enter it."
3120 GOTO 3030
3130 PRINT:INPUT"Enter the new wind speed";WSNEW
3140 PRINT:INPUT"Enter the new duration";DURNEW
3150 PRINT:PRINT"You entered";
3160 PRINT USING"###.#";WSNEW;
3170 PRINT" knots for ";
3180 PRINT USING"###.#";DURNEW;
3190 PRINT" hours."
```

```
3200 PRINT:INPUT"Is this correct";AN$
3210 TEST$=LEFT$(AN$,1)
3220 IF TEST$="Y" GOTO 3260
3230 IF TEST$="y" GOTO 3260
3240 PRINT:PRINT"So, do it again, or just duplicate what is there."
3250 GOTO 3030
3260 WS(LCHANGE)=WSNEW
3270 HOURS(LCHANGE)=DURNEW
3280 RETURN
```

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.