~~Dr. Glahn~~
file

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
SYSTEMS DEVELOPMENT OFFICE
TECHNIQUES DEVELOPMENT LABORATORY

TDL OFFICE NOTE 81-1

# A USER`S GUIDE TO COSMOS
# (COMPOSITE OIL SPILL MODEL FOR OPERATIONAL SERVICES)

Kurt W. Hess

January 1981

CONTENTS

PREFACE

This User`s Guide is meant to describe the use of the National Weather Service`s oil spill behavior forecast model, COSMOS (Composite Oil Spill Model for Operational Services), produced by the Techniques Development Laboratory. The model is designed to predict the behavior of floating oil from a fixed source point in the coastal zone (shore line out to 360 miles), excluding small bays. A forecast of the oil slick geometry for each 12 hours, out to 48 hours is plotted on a background map showing the local coastline. The primary input data for the model are the latitude and longitude of the spill site, the width of the map desired, the oil flow rate, and the initial distribution of oil on the water. Wind forecasts for the spill are made automatically by COSMOS using atmospheric model pressure and temperature forecasts.

This manual contains a brief description of the model physics, and gives a detailed explanation of the input data format. Sample runs and outputs are given in appendices to help acquaint the model user with COSMOS.

# USER`S GUIDE TO COSMOS
# (COMPOSITE OIL SPILL MODEL FOR OPERATIONAL SERVICES)

Kurt W. Hess

## 1. INTRODUCTION

COSMOS is the National Weather Service`s (NWS`s) oil spill behavior model. This version computes the two-dimensional motion of a finite thickness of oil at the sea surface under the action of wind stress and water currents. The position of the oil slick is plotted each 12 hours on a map which includes the local geography.

The user gives the latitude-longitude coordinates of the spill, and COSMOS goes to the Limited-area Fine Mesh (LFM) model 1000-mb forecasts of pressure and temperature to compute the surface geostrophic wind. Then COSMOS uses a steady Rossby number similarity model of the planetary boundary layer to compute the wind stress at the sea surface. This stress drives a hydrodynamic model of the continiential shelf region, which computes horizontal velocities and water surface elevations. Then the current at the surface is used to calculate the stress at the under side of the oil. Another model for two-dimensional oil motion is used to compute the time history of the oil slick. The positions of oil on the water are drawn on a map which uses the National Meteorological Center (NMC) geography files. Map width (degrees) and height can vary.

COSMOS is accessed by the program WE1OILY7. The data necessary to run COSMOS is stored on five files, and these data can be changed at will for specific user needs. The following is a brief description of the technical aspects of COSMOS. For more details, refer to Hess and Kerr (1979).

## 2. MODEL PHYSICS

The vector equation for oil motion comes from the depth-integrated form of the horizontal fluid momentum equation. The mass equation comes from the vertically-integrated continuity equation and gives the oil thickness. The equations are solved on a finite-difference grid of 1-km size. The mass equation uses a mass flux correction scheme to eliminate nearly all artificial diffusion. The vector momentum and mass conservation equations are:

$$\frac{\partial \underset{\sim}{u}}{\partial t} = - \frac{\rho_w - \rho_o}{\rho_o} g \nabla h + \frac{1}{\rho_o} (\underset{\sim}{\tau}_s - \underset{\sim}{\tau}_b) + f \hat{k} \times \underset{\sim}{u}, \text{ and}$$

$$\frac{\partial h}{\partial t} = - \nabla \cdot (h \underset{\sim}{u})$$

where $\tilde{u}$ = oil velocity vector (m/s),
$\rho_w$ = mass density of water (gm/cc),
$\rho_o$ = mass density of oil (gm/cc),
$g$ = gravitational acceleration ($m/s^2$),
$h$ = oil thickness (m),
$\tilde{\tau}_s$ = surface tangential stress vector $(\frac{gm - m}{s - cm^3}) = \rho_a V_*^2$,
$\rho_a$ = mass density of air (m/s),
$V_*$ = friction velocity of air (m/s),
$\tilde{\tau}_b$ = bottom tangential stress vector $(\frac{gm - m}{s - cm^3})$,
$f$ = Coriolis parameter ($s^{-1}$), and
$\hat{k}$ = unit vector in the vertical.

The wind stress is obtained by applying an atmospheric boundary layer model (BLM) to compute the friction velocity and surface deflection angle. The input for this BLM is the geostrophic wind computed from the LFM 1000-mb heights and 1000-mb temperatures. Implicit equations for the friction velocity and deflection angle, based on Rossby number similarity, are:

$$\ell n(R_o) = A - \ell n(V_*/G) + ((kG/V_*)^2 - B^2)^{1/2} \text{ and}$$

$$\sin(\alpha) = BV_*/kG$$

where $R_o$ = surface Rossby number = $G/fZ_o$,
$G$ = magnitude of the geostrophic wind (m/s),
$Z_o$ = surface roughness height (m) = $0.035V_*^2/g$,
$A$ = $1.1 + 0.20\ S_x - 0.40\ S_y$,
$B$ = $4.3 - 0.32\ S_x - 0.35\ S_y$,
$S_x$ = $-(k/f)^2\ (g/T)\ \partial T/\partial x$,
$S_y$ = $(k/f)^2\ (g/T)\ \partial T/\partial y$,
$T$ = boundary layer temperature (°K),
$k$ = von Karman's constant = 0.40, and
$\alpha$ = deflection angle from geostrophic wind to the stress vector.

Surface water currents are computed on a grid representing the local bathymetry by the equations of momentum balance and continuity. The vertically-integrated flow rate is computed with the storm surge equations and wind stress; the botton stress condition is the slip relationship (Jelesnianski, 1967). Continuity is used to find the surface elevation. Then the horizontal pressure gradient can be used in the horizontal momentum equation. The equation is solved with the same surface and botton stresses. This equation is:

$$\frac{\partial w}{\partial t} = p - ifw + \frac{\partial}{\partial z}\left(E\frac{\partial w}{\partial z}\right) - rw$$

where $w$ = complex horizontal velocity (m/s),
$p$ = complex horizontal pressure gradient term ($m/s^2$),
$i$ = $(-1)^{1/2}$,
$E$ = vertical eddy viscosity ($m^2/s$), and
$r$ = linear damping factor ($s^{-1}$).

Eddy viscosity varies from a surface value, $E_o$, linearly increasing with depth to a value $E_1$ at depth $D_1$, and remains constant down to the bottom of the mixed layer, of depth $D_e$. Here

$$E_o = kWZ_o \ (m^2/s),$$
$$W_* = \text{water friction velocity (m/s)} = (\underset{\sim}{\tau}_s/\rho_w)^{1/2}$$
$$E_1 = 0.004\ W_*^2/f \ (m^2/s),$$
$$D_1 = E_1/k \ (m), \text{ and}$$
$$D_e = 0.25\ W_*/f \ (m).$$

## 3. OPERATIONAL USE OF THE MODEL

COSMOS is permanently mounted on NWS production files for ready access on short notice. The model program takes less than a minute to execute, and has an operational priority for running on the NMC computer in Suitland, Md. COSMOS is accessible by submitting a batch or time-share job at an available terminal. If a remote terminal is unavailable, results of the model run can be telecopied to the field user.

For each oil spill, the input data expected to change are the latitude-longitude coordinates of the site, the width of the map upon which the oil slick is plotted, the initial distribution of oil on the water, and possibly the oil flow rate. Oil density is assumed to be 0.950 grams per cubic centimeter, and its value has little influence on the predicted oil behavior. Oil surface tension effects are not included in the model. Although COSMOS makes its own wind forecasts out to 48 hours over the coastal region around the oil spill, the user has the option of substituting his or her own wind forecast.

The output for COSMOS is given on files FT06F001, FT08F001, and FT12F001, of which the last is the most important. FT12F001 contains a list of the input data, a table giving the wind forecasts at the oil spill site, and a set of five maps, one each for the 0-,12-,24-,36-, and 48-h forecasts (see Appendix III). Each map shows the local coastline and oil slick in a region centered about the latitude-longitude of the spill with the given map width. The heading block of each map explains what the various map symbols mean and gives the volume of spilled oil depicted.

File FT08F001 contains an array depiction of the oil corresponding to each map. The relative oil thickness, as a log of the ratio of thickness to the scale thickness, is given with the volume, in thousands of gallons. These data can be used as input, in file FT10F001, when making the next day's forecast. File FT06F001 contains details of the model calculations.

Data input for COSMOS is through several files. For the first day's run, the spill latitude and longtitude and the map width are reset in file FT05F001 (see Appendix IV). Initial volume and distribution of oil are specified in FT10F001. And the flow rate, in thousands of gallons per day, is specified in

FT35F001. After any changes are made in the input files, the program is submitted for execution, and output returns shortly thereafter (usually within 5 minutes).

Other options the user is likely to exercise are described in the next section, in file FT05F001. The main features allow the user to:

a. shift the spill site on the map using ID4, ID6, and ID7,
b. read in 6-hourly, spatially constant water currents with ID10,
c. read in 6-hourly winds (ID11) to modify or substitute for the wind forecast,
d. change the LFM input data cycle time (ID12),
e. add constant water velocities (WSNORT, WSEAST), and
f. add a wave drift equal to a percentage (DFAX) of wind speed.

Furthermore, the user can change variables in the common blocks in the program (Appendix IV). Variables such as oil density (RHOO) and the oil-water interfacial drag coefficient (CDRGOW) can be altered this way.

## 4. DESCRIPTION OF THE DATA INPUT FILES

File FT05F001 — This file contains the essential model data and determines what other files are to be read.

Card 1 — ID1,ID2,ID3,ID4,ID5,ID6,ID7,ID8,ID9,ID10, ID11,ID12,WSNORT,WSEAST,STRTCH,DFAX,DANG, TAMS,JD1,JD2,JD3. FORMAT(12I3,6F5.2,3I3).

ID1 = Model level:
1=Make a wind forecast only.
3=Run the full composite model.

ID2 = Width of map field (degrees), with a maximum of 14. Width is 80 spaces, height is 80-ID6-ID7 spaces. Height in degrees varies with latitude.

ID3 = Oil source at wind site (0=no, 1=yes)

ID4 = Number of plot spaces the source is moved to left from the center ($39 \geq ID4 \geq -39$).

ID5 = Number of NMC model (0=LFM2, 2=Spectral) (COSMOS is presently set up to use only the LFM).

ID6 = Number of lines at top of geography array not plotted (if both ID6 and ID7 are zero, a default value of 20 is assumed for both).

ID7 = Number of lines at bottom of geography array not plotted.

ID8 = Maximum forecast projection time + 1 (hours).

ID9 = (Vacant).

ID10 = Read in 6-hourly water velocities (0=no,1=yes) (if ID10=0, WNO = WEA = 0.).

ID11 = Read in 6-hourly wind velocities:
0=No.
1=Multiply forecast wind by AD10 and add angle APHI (APHI is in degrees and is measured clockwise from east. Direction is that toward which the wind blows).
2=Substitute AD10 (kt) and APHI for forecast wind.

ID12 = Override time of latest NMC forecast (0=no,1=yes).

WSNORT = Constant water speed to the north (m/s) added to the computed current.

WSEAST = Constant water speed to the east (m/s) added to the computed current.

STRTCH = Stretch factor for plotting (0.00=TSO, 0.41=HETRA).

DFAX = Percent of wind speed (square root of stress) assumed for wave (Stokes) drift.

DANG = (Vacant).

TAMS = Temperature of air minus that of sea (°C) (Non-neutral version not fully tested. Keep=0.00).

JD1 = Print out wind and drift calculations (0=no,1=yes).

JD2 = Print out grid setup calculations (0=no,1=yes).

JD3 = Print out water velocity and oil calculations (0=no,1=yes).

Card 2 PLAT, PLON
FORMAT (2F7.2)

PLAT = North latitude (°) of oil spill site.

PLON = West longitude (°) of oil spill site.

<u>File FT10F001</u> This file contains information about the initial slick position and volume. Output in this format is printed each 12 hours on file FT08F001.

Card 1 GAL,DL,MA,MB,NA,NB
FORMAT(2F10.2,4I4)

GAL = Initial oil volume, thousands of gallons.

DL = Grid length (m).

MA,MB = First and last row with oil 50 x 50 grid (numbering from top to bottom).

NA,NB = First and last column with oil (left to right).

Cards 2 to J
J=MB-MA+2
(IH(N,M),N=NA,NB) on row M.
FORMAT (50I1)

IH = Log10 of (oil thickness/minimum thickness)(see output file FT08F001 for a sample of the IH array).

<u>File FT15F001</u>

This file contains additional water speeds (m/s) which are added to the surface wind drift current. Only read if ID10=1. WNO is the current to the north, WEA is current to the east. Values are for each 6 hours from 0 out to 48 hours.

Card 1 WNO(I),I=1,9 FORMAT(9F7.2)

Card 2 WEA(I),I=1,9 FORMAT(9F7.2)

<u>File FT25F001</u>

This file contains wind speed and direction forecasts which replace those generated by the LFM and boundary-layer models in COSMOS. Speed is in knots and angle is degrees clockwise from east. Read only if ID11=1. Values are for each 6 hours from 0 out to 48 hours.

Card 1 AD10(I),I=1,9 FORMAT(9F7.2)

AD10 = Wind speed at 10 meters (kt) each 6 hours.

Card 2 APHI(I),I=1,9 FORMAT(9F7.2)

APHI = Wind direction at 10 meters ($^{o}$) each 6 hours.

<u>File FT35F001</u>

This file contains the position and status of initial oil slick on the surface. Grid size and oil volume (thousands of gallons). First card always read.

Card 1 MAXST,IDAY FORMAT(2I3)

MAXST = Number of oil model timesteps (at 72 per day, the usual model 2-d forecast will have 144 steps).

IDAY = Number of values of GALDAY(N) to be read.

Card 2 (GALDAY(N),N=1,IDAY)
FORMAT(10F7.2)

GALDAY = Oil discharge rate (thousands of gallons per day).

## REFERENCES


Hess, K. W. and C. L. Kerr, 1979: A model to forecast the motion of oil on the sea. Proceedings 1979 Oil Spill Conference, Los Angeles, Amer. Petroleum Inst., Environ. Prot. Agency, U.S. Coast Guard, 653-663.

Jelesnianski, C. P., 1967: Numerical computations of storm surges with bottom stress. Mon. Wea. Rev., 95, 740-756.

## APPENDIX I

## SAMPLE RUN #1; SUBMITTING A JOB

The following is a step-by-step listing of terminal commands used to submit a run. The steps correspond to commands and responses listed on the next page. For batch processing, new data are punched on the cards and the deck is submitted.

| Step | Remarks |
|---|---|
| 1 | Log on the terminal. |
| 2 | Enter the user ID. |
| 3 | Set the number of printed characters per line to 130. |
| 4 | Using the quick editor option, enter the COSMOS program. |
| 5 | Enter the verify command to insure printing of changes. |
| 6 | Find the character +, which is in the first line of the data input cards. |
| 7 | Move down one line. |
| 8 | Change the latitude, 25 to 40. |
| 9 | Change the longitude to 80. |
| 10 | Move up one line. |
| 11 | Change the map width from 2 to 3 degrees. |
| 12 | Save the altered program. |
| 13 | Exit the quick editor. |
| 14 | Sub the job. |
| 15 | After the job runs, the user is notified. |

```
1  LOGON
   IKJ56700A ENTER USERID -
2  $WE20KH/MARINE SIZE(250)
   $WE20KH LOGON NOD 195 TSO AT 11:48:56 ON SEPTEMBER 5, 1980
   NO BROADCAST MESSAGES
   READY
3  TERMINAL LINESIZE(130)
   READY
4  QED 'NWS.SDO.TDL.PROD.HURICANE.SURGE.DATA(COSMO2)'
   QED
5  V
6  F /+/
   00690 +03  2  1  0  0  0  0 49  0  0  0  0 0.0  0.0  0.0  0.0 15.0  0.0 000
7  +
   00700   25.00  80.00
8  C /25/40/
   00700   40.00  80.00
9  C /80/73/
   00700   40.00  73.00
10 -
   00690 +03  2  1  0  0  0  0 49  0  0  0  0 0.0  0.0  0.0  0.0 15.0  0.0 000
11 C /2/3/
   00690 +03  3  1  0  0  0  0 49  0  0  0  0 0.0  0.0  0.0  0.0 15.0  0.0 000
12 S
   SAVED

13 END
   READY
14 SUB 'NWS.SDO.TDL.PROD.HURICANE.SURGE.DATA(COSMO2)'
   JOB WE1DILY7 SUBMITTED
   READY
   ST WE1DILY7
   IKJ028A STATUS REQUEST ACCEPTED
   READY
   IQ906 JOB 5253,WE1DILY7 PRTY=(10,17) R=(300K,300K),TBM(C),RI(C),MA(A),TBM(C),ACD
   S,PR,PU(C)


15 IEF404I WE1DILY7 ENDED         TIME=11.57.49
   ADSG19 DATA SET CATALOGED,  DATA SET NAME = $WE20KH.WE1DILY7.SYSMSG.DATA
   ADSG19 DATA SET CATALOGED,  DATA SET NAME = $WE20KH.WE1DILY7.SYSPRINT.DATA
   ADSG19 DATA SET CATALOGED,  DATA SET NAME = $WE20KH.WE1DILY7.FT06F001.DATA
   ADSG19 DATA SET CATALOGED,  DATA SET NAME = $WE20KH.WE1DILY7.FT08F001.DATA
   ADSG19 DATA SET CATALOGED,  DATA SET NAME = $WE20KH.WE1DILY7.FT12F001.DATA
```

## APPENDIX II

## SAMPLE RUN #2; LISTING A JOB OUTPUT

When the forecast for the oil behavior is made, the user retrieves the results. The steps correspond to commands listed on the following two pages.

| Steps | Remarks |
|---|---|
| 1 | Use the quick editor on the desired data set |
| 2 | Verify |
| 3 | List the output, starting from the top. All input data are shown, and a list of the forecast winds given. |
| 4 | Enter the BREAK command to stop the listing. |
| 5 | Look for the last map by asking to find the set of characters 48HR. |
| 6 | List 80 lines starting from this one. |
| 7 | Enter END. |

```
1 O   QED WE1DILY7.FT12F001.DATA
      DATASET NOT LINE NUMBERED-NONUM ASSUMED
      QED
2 O   V
3 O   L
       COSMOS, THE 'COMPOSITE OIL SPILL MODEL FOR OPERATIONAL SERVICES', IS AT WORK.
       **************************************************************************
       READ IN THE FIRST DATA CARD,
       1  2  3  4  5  6  7  8  9 10 11 12 W.NO W.EA S.TR D.FX D.AN T.AS J123
       3  3  1  0  0  0  0 49  0  0  0  0 0.0  0.0  0.0  0.0 15.00 0.0  000

       READ IN THE SECOND DATA CARD

         40.00  73.00   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0

       READ IN MAXST AND IGAL6H =  144     2
         10.00  10.00
       **************************************************************************

       WIND FORECAST AT LATITUDE= 40.00       LONGITUDE= 73.00

       PROGRAM RUN AT 1557 HR,  5 SEP 80, W/DATA FROM  5 SEP  0Z CYC OF LFM2

       HR(Z)    WIND SPEED AT 10 M     TO ANGLE (DEG)
                (M/S)         (KTS)    (+C.W. FROM EAST)
         0       2.7          5.2      265.
         6       2.3          4.5      294.
        12       3.4          6.6      290.
        18       2.0          3.9      306.
         0       2.6          5.1      313.
         6       2.6          5.0        3.
        12       2.7          5.3      346.
        18       1.7          3.3       20.
         0       2.3          4.4       35.

       --------------------------------------------------------------------------
4 O    TIME=  0HR.  OIL SLICK THIC:!
      QED
```

50 F /48HR/

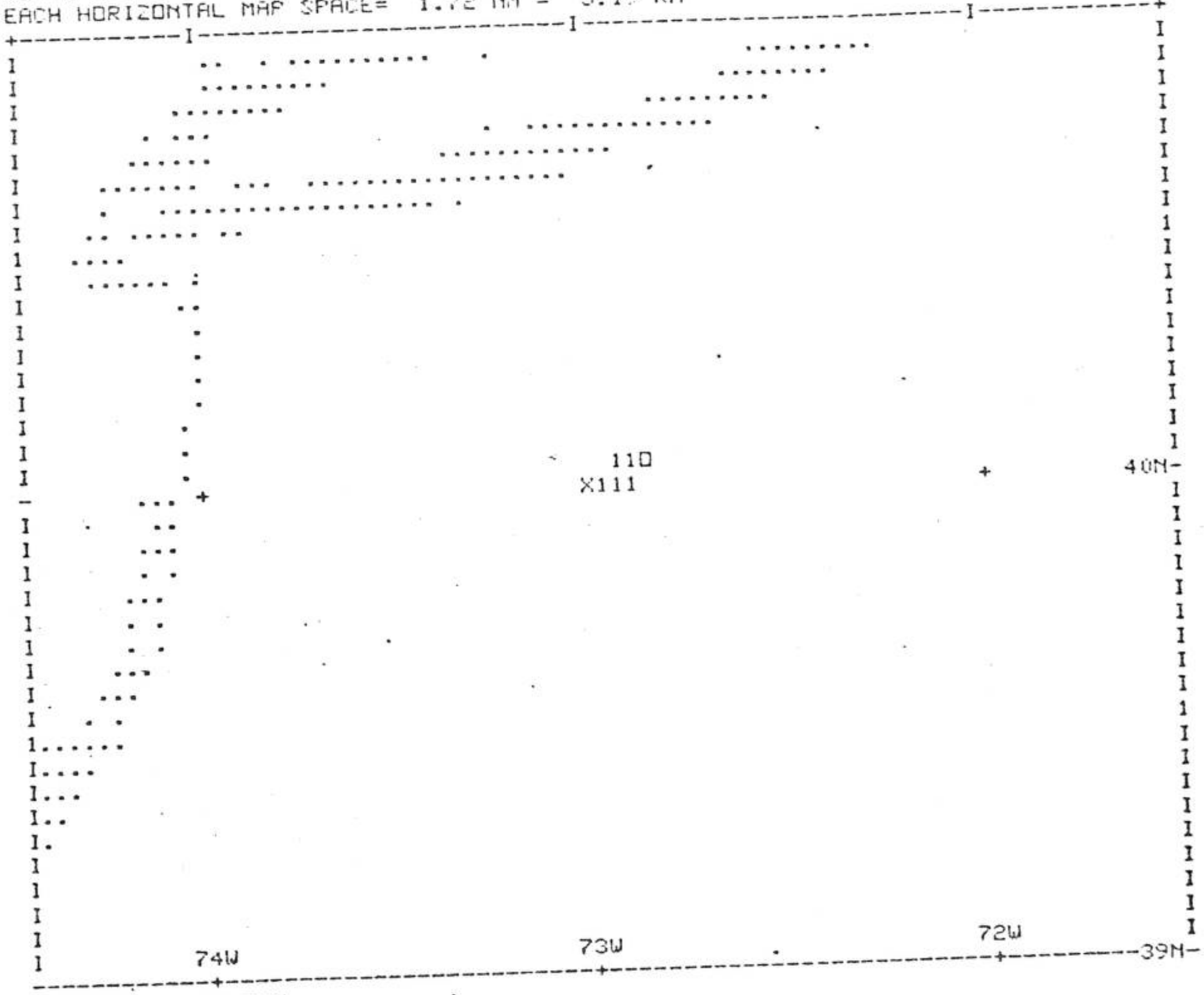
TIME= 48HR. OIL SLICK THICKNESS DISTRIBUTION FORECAST. NET OIL= 20500 GALI

60 L * 80

TIME= 48HR. OIL SLICK THICKNESS DISTRIBUTION FORECAST. NET OIL= 20500 GALI

KEY/X=SPILL SITE/.=COASTLINE/D.1,2,3=OIL ON WATER/*=BEACHED OIL= 0 GALI

EACH HORIZONTAL MAP SPACE= 1.72 NM = 3.19 KM




END OF COSMOS RUN

END OF DATA

## APPENDIX III

### SAMPLE OUTPUT FROM FILES

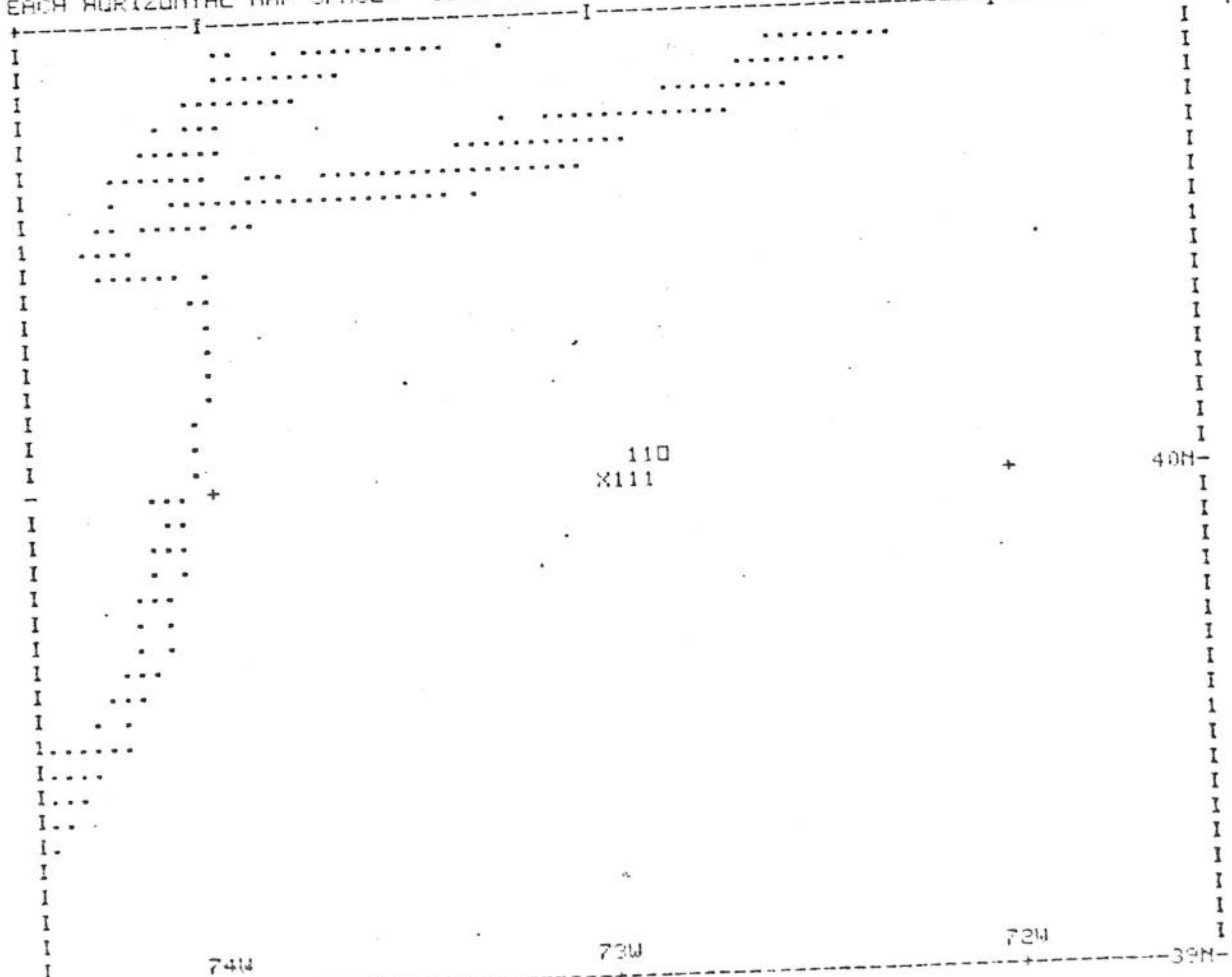
A. Sample Output from FT12F001 appears on page 15. The first 11 lines of text show the original data used for the run. The next 13 lines of text give the spill site and the wind forecast. The last 46 lines show the map of the spill region. The heading block gives the volume of the oil spilled, the time, and the volume of beached oil.

B. Sample Output from FT08F001 appears on page 16. For each time interval, the heading gives the time, the time step, and the volume of oil. The arrays of numbers below the headings give the oil thicknesses in logarithm form. Within the 50x50 array, only columns NA to NB and rows MA to MB contain oiled elements.

```
COSMOS, THE 'COMPOSITE OIL SPILL MODEL FOR OPERATIONAL SERVICES', IS AT WORK.
******************************************************************************
READ IN THE FIRST DATA CARD,
 1  2  3  4  5  6  7  8  9 10 11 12 W.MO W.EA S.TR D.FX D.AN T.AS J123
 3  3  1  0  0  0  0 49  0  0  0  0 0.0  0.0  0.0  0.0 15.00 0.0   000

READ IN THE SECOND DATA CARD
  40.00  73.00   0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0

READ IN MAXST AND IGAL6H =  144     2
  10.00  10.00
******************************************************************************

WIND FORECAST AT LATITUDE= 40.00      LONGITUDE= 73.00

PROGRAM RUN AT 1557 HR,  5 SEP 80, W/DATA FROM  5 SEP  0Z CYC OF LFM2
```

| HR(Z) | WIND SPEED AT 10 M (M/S) | (KTS) | TO ANGLE (DEG) (+C.W. FROM EAST) |
|---|---|---|---|
| 0 | 2.7 | 5.2 | 265. |
| 6 | 2.3 | 4.5 | 294. |
| 12 | 3.4 | 6.6 | 290. |
| 18 | 2.0 | 3.9 | 306. |
| 0 | 2.6 | 5.1 | 313. |
| 6 | 2.6 | 5.0 | 3. |
| 12 | 2.7 | 5.3 | 346. |
| 18 | 1.7 | 3.3 | 20. |
| 0 | 2.3 | 4.4 | 35. |

```
TIME= 48HR.  OIL SLICK THICKNESS DISTRIBUTION FORECAST. NET OIL=     20500 GALI
KEY/X=SPILL SITE/.=COASTLINE/0,1,2,3=OIL ON WATER/*=BEACHED OIL=         0 GALI
EACH HORIZONTAL MAP SPACE=  1.72 NM =  3.19 KM
```




END OF COSMOS RUN

```
STEP=   0  TIME(HR)=    0.0   END OF DAY  0.0  NS=25 MS=25
MA= 3  MB=48  NA= 3  NB=48  GAL=        0.0  CL= 1000.00


STEP=  36  TIME(HR)=   12.00  END OF DAY  0.50 NS=25 MS=25
MA=20  MB=29  NA=22  NB=30  GAL=     5419.1  CL= 1000.00

20   000000000
21   000000000
22   000344300
23   000454300
24   000444000
25   000430000
26   000020000
27   000000000
28   000000000
29   000000000

STEP=  72  TIME(HR)=   24.00  END OF DAY  1.00 NS=25 MS=25
MA=17  MB=27  NA=22  NB=33  GAL=    10537.5  CL= 1000.00

17   000000000000
18   000000000000
19   000000003300
20   000000044400
21   000002344400
22   000000444300
23   000003440000
24   000344430000
25   000444400000
26   000000000000
27   000000000000

STEP= 108  TIME(HR)=   36.00  END OF DAY  1.50 NS=25 MS=25
MA=15  MB=28  NA=23  NB=37  GAL=    15518.9  CL= 1000.00

15   000000000000000
16   000000000000000
17   000000000000000
18   000000000002000
19   000000000003300
20   000000000044300
21   000000000354300
22   000000002444000
23   000000004430000
24   000003444000000
25   004444444000000
26   000344440000000
27   000000000000000
28   000000000000000

STEP= 144  TIME(HR)=   48.00  END OF DAY  2.00 NS=25 MS=25
MA=17  MB=30  NA=23  NB=40  GAL=    20500.2  CL= 1000.00

17   000000000000000000
18   000000000000000000
19   000000000000000000
20   000000000000020000
21   000000000000023200
22   000000000000444300
23   000000000002444000
24   000000000024443000
25   004442222244400000
26   004444444444000000
27   000444444444000000
28   000003344400000000
29   000000000000000000
30   000000000000000000
```

## APPENDIX IV

## JCL AND DATA LISTING

The following is a listing of the COSMOS program JCL and data which are stored in data set NWS.SDO.TDL.PROD.HURRICANE.SURGE.DATA(COSMOS2)

```
//WE10ILY7 JOB (WE27003C6982024,TDL-10),HESS,TIME=(1,00),REGION=300K,
// NOTIFY=WE20KH
//*MAIN CLASS=NMCOPER1
//*FORMAT AC,DDNAME=SYSMSG,PRINT=YES
//*FORMAT AC,DDNAME=SYSPRINT,PRINT=YES
//*FORMAT AC,DDNAME=FT06F001,PRINT=YES
//*FORMAT AC,DONAMF=FT08F001,PRINT=YES
//*FORMAT AC,DDNAME=FT12F001,PRINT=YES
//*FORMAT PR,DDNAME=,DEST=GRANX,CONTROL=SINGLE
// EXEC NWSCPYFM,CYCLE=00Z
//COPY.FT06F001 DD DUMMY
// EXEC NWSCPYFM,CYCLE=12Z
//COPY.FT06F001 DD DUMMY
// EXEC NFORXCLG,PARM.FORT=xL,PARM.LKED='OVLY,LET,LIST,MAP'
//FORT.SYSIN DD *
      BLOCK DATA
C        APRIL 1979   K. W. HESS   TDL   IBM 360/195
C        PURPOSE - TO INITIALIZE MANY OF THE COSMOS CONSTANTS
C        VARIABLES -
C                 CL = OIL MODEL GRID SIZE
C              LPRIN = (UNUSED)
C             MSORCE = X-DIR (DOWN) OIL GRID INDEX OF SPILL SITE
C             NSORCE = Y-DIR (RIGHT) OIL GRID INDEX OF SPILL SITE
C                SUM = SUM OF ALL H(N,M) ON OIL GRID
C             UNAREA = RATIO OF SINGLE GRID AREA TO ORIGINAL AREA
      COMMON/AUX4/CL,IGRID,SUM,UNAREA,LPRIN,NSORCE,MSORCE
      DATA CL,SUM,UNAREA,LPRIN,NSORCE,MSORCE/1000.,0.0,1.0,1,25,25/
      END
      BLOCK DATA
C        APRIL 1979   K. W. HESS   TDL   IBM 360/195
C        PURPOSE - TO INITIALIZE MANY OF THE COSMOS CONSTANTS
C        VARIABLES -
C                 AT = TIMESTEP OF THE HYDRODYNAMIC MODEL (S)
C                 AG = GRAVITATIONAL ACCELERATION (M/S**2)
C                 AL = HYDRO MODEL GRID SIZE (M)
C                 CG = OIL MODEL GRAV. ACCELERATION (M/S**2)
C                 CL = OIL MODEL GRID SIZE (M)
C             CDRGAW = AIR-WATER INTERFACIAL DRAG COEFFICIENT
C             CDRGOW = OIL-WATER INTERFACIAL DRAG COEFFICIENT
C            CMU,CMS = FACTORS MULTIPLYING WATER VELOCITIES FOR PRINT
C             CVISC1 = FRACTION OF LATEST EDDY VISCOSITY USED TO UPDATE
C             CVISC2 = (UNUSED)
C             CVISC3 = EDDY VISCOSITY COEFFICIENT (E1=CVISC3*WST**2/F)
C             CVISC4 = (UNUSLD)
C             CVISC5 = (UNUSED)
C              FRICT = LINEAR DAMPING COEFFICIENT, WATER TRANSPORT EQN
C               FSIG = (UNUSED)
C             GRDANG = ANGLE HYDRO BASLINE ROTATED CW FROM NORTH (DEG)
C             INTVEL = POINTS SKIPPED IN GRAPH ROUTINE
C             IPSEUV = INDEX FOR WATER PRINTOUT(01=VEL,10=TIME,11=BOTH)
C             ISTART = FIRST POINT IN GRAPH ROUTINE
C                 IT = ARRAY HOLDING HYDRO GRID INDICES (WATER,LAND)
C               MHAX = MAXIMUM X-DIMENSION (+DOWN) OF HYDRO GRID
C              MODE1 = INDEX FOR WINDS (0=BLM, 1=FT05)
C              MODE2 = INDEX FOR HYDRO (0=ZDATA2, 1=XDEPTH)
C              MODE3 = (UNUSED)
```

```
C                  MX1 = MAXIMUM X-DIMENSION (+DOWN) OF HYDRO GRID
C                 NMAX = MAXIMUM Y-DIMENSION (+RIGHT) OF HYDRO GRID
C                  NS1 = NUMBER OF HYDRO MODEL STEPS PER OIL MODEL STEP
C                  NX1 = MAXIMUM Y-DIMENSION (+RIGHT) OF HYDRO GRID
C                NSURF = NUM. OF HYDRO STEP WHEN CALCULATE SURF. VEL
C                NVELS = NS1
C                NSTEP = NUMBER OF HYDRO STEP (1 TO NS1)
C                NVISC = NUM. OF OIL STEPS TO CALC. EDDY VISCOSITY
C               RATRAW = AIR-WATER DENSITY RATIO
C               RATRAO = AIR-OIL DENSITY RATIO
C               RATROW = OIL-WATER DENSITY RATIO
C                 RHOA = AIR DENSITY (GM/CC)
C                 RHOO = OIL DENSITY (GM/CC)
C                 RHOW = WATER DENSITY (GM/CC)
C                SIGMA = (UNUSED)
C                 SLIP = HYDRO MODEL BOTTOM STRESS COEFF=TAU/VEL
C                    U = WATER TRANSPORT IN X-DIRECTION (M**2/S)
C                    V = WATER TRANSPORT IN Y-DIRECTION (M**2/S)
C                 VISC = INITIAL EDDY VISCOSITY, E1 (M**2/S)
C                   X0 = X-COORD OF OIL SPILL ON HYDRO GRID
C                   Y0 = Y-COORD OF OIL SPILL ON HYDRO GRID
C                 ZMAX = MAXIMUM DEPTH OF MIXED LAYER (M)
      COMMON/MOD1/MODE1,MODE2,MODE3
      COMMON/HS4/NSURF,DT,FRICT
C
C
C
      COMMON/DRW2/ISTART,INTVEL,NSTMAX
      COMMON/HYD1/U(30,50),V(30,50),IT(30,50),NMAX,MMAX,NVELS,NSTEP
      COMMON/HYD2/SLIP,VISC,COR,AT,AG,AL,A_AT,CORGAW
      COMMON/OIL2/CT,CG,CORGOW,FSIG,X0,Y0,GRDANG,IDAYS
      COMMON/PRP1/RHOO,RHOW,RHOA,SIGMA,CL1,RATRAO,RATROW,RATRAW
      COMMON/PRT1/NPRNT1,NPRNII,CMS,CMU,IPSEUV
      COMMON/VEL1/ZMAX,NX1,NX2,MX1,MX2,NS1,NS2
      COMMON/VIS1/NVISC,CVISC1,CVISC2,CVISC3,CVISC4,CVISC5
      DATA RHOO,RHOW,RHOA,SIGMA/0.950,1.025,0.00120,000./
      DATA MODE1,MODE2,MODE3,NS1/0,0,0,2/
      DATA SLIP,VISC,AT,AG,AL,CORGAW/.002,.01,600.,9.81,19300.,.0010/
      DATA NMAX,MMAX,NVELS,X0,Y0,NSURF,GRDANG/30,50,2,15.,25.,2,0./
      DATA ZMAX,NX1,NX2,MX1,MX2/45.,1,30,1,50/
      DATA FRICT,CT,CG,CORGOW,FSIG,CMU,CMS/.6,1200.,9.31,.003,1.,2*100./
      DATA U,V,IT,IPSEUV,INTVEL,NSTEP,ISTART/3000*0.,1500*0,01,100,1,1/
      DATA NVISC,CVISC1,CVISC2,CVISC3,CVISC4,CVISC5/9,.5,0.,.004,0.,0./
      END
//LKED.SYSLIB DD
// DD
// DD DSN=NWS.NMC.W3LIB.LOAD,DISP=SHR
//LKED.HESMES DD DSN=NWS.SDO.TDL.PROD.HURICANE.SURGE.DATA,DISP=SHR
//LKED.HESMOD DD DSN=NWS.SDO.TDL.PROD.HURICANE.SURGE.LOAD,DISP=SHR
//LKED.SYSIN DD *
 ENTRY MAIN
  INCLUDE HESMOD(KHMOD1)
 OVERLAY ALFA
  INCLUDE HESMOD(KHMOD2)
 OVERLAY ALFA
  INCLUDE HESMOD(KHMOD3)
  INCLUDE SYSLIB(W3AI01,W3FK00,W3FK01,W3FK03,W3FK09,W3FQ02,XMOVEX)
  INCLUDE SYSLIB(FORTXDAM,VSOPEN,VSOPNX,VSWRIT,VSREAD,VSCLOS)
 OVERLAY ALFA
  INCLUDE HESMOD(KHMOD4)
  INCLUDE SYSLIB(GETGEO)
 OVERLAY ALFA
  INCLUDE HESMOD(KHMOD5)
 OVERLAY ALFA
  INCLUDE HESMOD(KHMOD6)
//GO.FT03F001 DD DSN=NCS.SAP.DMK.GEO03,DISP=SHR
//GO.FT03F002 DD DSN=NCS.SAP.DMK.GEO04,DISP=SHR
//GO.FT04F001 DD DSN=NWS.SDO.TDL.PROD.HURICANE.SURGE.DATA(ZDATA2),
// DISP=SHR,LABEL=(,,,IN)
//GO.FT13F001 DD DSN=W,NWS.W427.KH.SORCE.DATA1,
// DISP=SHR,LABEL=(,,,OUT)
```

```
//GO.SYSIN DD *
+03   2   1   0   0    0   0 49   0   0   0   0 0.0   0.0   0.0   0.0 15.0   0.0 000
  34.20 119.70
//GO.FT10F001 DD *
      0.00        0.00    0    0    0    0
1000
0100
0010
0001
//GO.FT15F001 DD *
  00.00  00.00
  00.00  00.00
    (WNO, WEA)
//GO.FT25F001 DD *
  00.00  00.00
  00.00  00.00
    (AV10, APHI)
//GO.FT35F001 DD *
144  2
  10.00  10.00
     (MAXST, DAYS)
     (GALDAY(I),I=1,DAYS, IN THOUSANDS OF GALLONS)
//FT06F001 DD SYSOUT=A
//FT08F001 DD SYSOUT=A
//FT12F001 DD SYSOUT=A
//FM0000 DD DSN=&&FM0000Z,DISP=OLD
//FM1200 DD DSN=&&FM1200Z,DISP=OLD
//FM2400 DD DSN=&&FM2400Z,DISP=OLD
//FM3600 DD DSN=&&FM3600Z,DISP=OLD
//FM4800 DD DSN=&&FM4800Z,DISP=OLD
//FM0012 DD DSN=&&FM0012Z,DISP=OLD
//FM1212 DD DSN=&&FM1212Z,DISP=OLD
//FM2412 DD DSN=&&FM2412Z,DISP=OLD
//FM3612 DD DSN=&&FM3612Z,DISP=OLD
//FM4812 DD DSN=&&FM4812Z,DISP=OLD
//
```

## APPENDIX V

## LISTING OF MAIN PROGRAM

The following is a listing of the main program called in the program COSMOS.

```
//WEKHLS1A JOB (WE2700AC6382024,GRAMX-10),'KURT HESS',CLASS=R,
// REGION=256K,MSGLEVEL=(1,1),TIME=(,20),NOTIFY=$WE20KH
//*FORMAT PR,DDNAME=,DEST=GRAMX,CONTROL=SINGLE
// EXEC NFORXCL,PARM.FORT='OPT(3),MAP,XREF,XL'
//FORT.SYSIN DD *
C*****MAIN PROGRAM FOR THE NWS OIL SPILL BEHAVIOR MODEL
C
C        MAY 1979     HESS     TDL     IBM 360/195
C
C        PURPOSE
C            TO READ LFM FIELDS, COMPUTE GEOSTROPHIC WINDS FOR A LOCAL
C            BOUNDARY LAYER MODEL TO GET SURFACE WINDS AND STRESSES.
C            ALSO TO COMPUTE OIL DRIFT TRAJECTORIES BASED ON A PERCENT
C            OF THE WIND SPEED , OR TO COMPUTE TOTAL OIL BEHAVIOR
C            BASED ON ACCELERATIONS OF OIL DUE TO WIND AND WATER STRESS.
C            OUTPUT IS A GEOGRAPHIC MAP WITH OIL DISTRIBUTION EACH 6 HRS
C
C        DATA SET USE
C            FT03 - NMC GEOGRAPHY DATA SETS (INPUT)
C            FT04 - HESS BASIN DATA FILES (INPUT)
C            FT05 - GENERAL DATA (INPUT)
C            FT06 - GENERAL PRINTING (OUTPUT)
C            FT08 - SURFACE DRIFT POSITION ARRAY (OUTPUT)
C            FT09 - SPLASH BASIN DATA SETS (INPUT)
C            FT10 - INITIAL SURFACE DRIFT POSITIONS (LEVEL=2) (INPUT)
C                   OR INITIAL 2-D OIL DISTRIBUTION (LEVEL=3) (INPUT)
C            FT12 - FORECAST WINDS AND OIL POSITION PLOTS (OUTPUT)
C            FT15 - ADDITIONAL WATER SURFACE VELOCITIES (INPUT)
C            FT25 - REPLACEMENT WIND FORECASTS (INPUT)
C            FT35 - NUMBER OF STEPS AND GALLONS OF OIL SPILLED (INPUT)
C                   (LEVEL=3 ONLY)
C
C        VARIABLES
C                  ID1 = MODEL LEVEL
C                        0 = DRAW MAP ONLY
C                        1 = COMPUTE SURFACE WINDS ONLY
C                        2 = RUN THE DRIFT MODEL
C                        3 = RUN THE TWO-DIMENSIONAL OIL BEHAVIOR MODEL
C                  ID2 = WIDTH OF MAP FIELD (DEGREES)
C                  ID3 = OIL SOURCE AT WIND SITE (0=NO, 1=YES)
C                  ID4 = NUMBER OF PLOT SPACES THE SOURCE IS MOVED TO
C                        LEFT FROM THE CENTER.
C                  ID5 = NUMBER OF NMC MODEL (0=LFM2, 1=7LPE)
C                         (COSMO IS PRESENTLY SET UP TO USE ONLY THE LFM)
C                  ID6 = NUMBER OF LINES AT TOP OF GEOG ARRAY NOT PLOTTED
C                         (IF BOTH ID6 AND ID7 ARE ZERO, A DEFAULT VALUE
C                         OF 20 IS ASSUMED FOR BOTH)
C                  ID7 = NUMBER OF LINES AT BOT OF GEOG ARRAY NOT PLOTTED
C                  ID8 = MAXIMUM FORECAST PROJECTION TIME (IF NOT 48 HR)
C                  ID9 = NUMBER OF INITIAL LAT/LON POINTS OF OIL PRESENT
C                 ID10 = READ IN INITIAL 6-HOURLY WATER VELS (0=NO,1=YES)
C                         (IF ID10=0, WNO = WEA = 0.)
C                 ID11 = READ IN INITIAL 6-HOURLY WIND VELS (0=NO,1=YES)
C                 ID12 = OPTION TO CHANGE IZZ (0=NO,1=YES)
C                        IF LEVEL=3,
C                           1=WIND TIMES AD10, ANGLE ROTATED APHI DEG CW
C                           2=WIND IS AD10 KTS, ANGLE IS APHI
```

```
C               WSNORT = CONSTANT WATER VEL (NORTH) ADDED TO WIND (M/S)
C               WSEAST = CONSTANT WATER VEL (EAST ) ADDED TO WIND (M/S)
C               STRTCH = STRETCH FACTOR FOR PLOTTING(0.=TSC,.41=HETRA)
C                DFACT = NET WIND DRIFT FACTOR
C                 DFAX = WIND OR WAVE DRIFT FACTOR (PCT)
C                 DANG = ANGLE OF WATER DRIFT TO RIGHT OF WIND (DEG)
C                 TAMS = TEMP OF AIR MINUS TEMP OF SEA (DEG. C)
C                  JD1 = PRINT OUT WIND AND DRIFT CALCS (0=NO, 1=YES)
C                  JD2 = PRINT OUT BASIN AND GRID SETUP CALCS(0=NO,1=YES)
C                  JD3 = PRINT OUT WATER VEL AND OIL CALCS(0=NO,1=YES)
C              PLAT(I) = LATITUDE (DEG) OF OIL (I=1 IS SPILL SITE)
C              PLON(I) = LONGITUDE(DEG) OF OIL (I=1 IS SPILL SITE)
C               WNO(J) = 6-HOURLY WATER VELOCITIES (M/S) NORTH
C               WEA(J) = 6-HOURLY WATER VELOCITIES (M/S) TO EAST
C              AD10(J) = 6-HRLY FORECAST WIND SPEED (KTS)
C              APHI(J) = 6-HRLY FORECAST WIND DIR (DEG CLOCKWISE FROM E)
C                MAXST = MAXIMUM NUMBER OF TIMESTEPS IN COMPOSITE MODEL
C             GAL6H(I) = NUMBER OF GALLONS OF OIL SPILLED PER 24HR PERIOD
C                        (IN THOUSANDS)
C                  IZZ = CYCLE TIME (1=0Z, 2=12Z)
C                JTMAX = MAXIMUM FORECAST PROJECTION TIME PLUS 1 (HRS)
C
      COMMON/BASIN/SLAT,SLON,IBASIN,CLAT(50),CLON(50)
      COMMON/BASN4/LSTAT(30),$BSN
      COMMON/DRFT2/WSNORT,WSEAST,PLAT(25),PLON(25),STRTCH,INTLOC
      COMMON/DRFT3/WNO(15),WEA(15),DFACT,DANG
      COMMON/GEOG1/IRES,KCEN,LCEN,JSHIFT,LLAT(14),KLON(14),JPL(80,80)
      COMMON/GRIDS/NC,MC,IC,IDX,XPOINT,YPOINT
      COMMON/GRID2/XP,YP,RA,CG1,CG2,GL,JTMAX
      COMMON/GWND1/JTIME,IZZ,ID1,ID2,ID3,ID4,ID5
      COMMON/GWND2/AV10(20),AD10(20),APHI(20)
      COMMON/GWND4/ID6,ID7,ID8,ID9,ID10,ID11,ID12
      COMMON/OIL3/NOUT,NOUT1,IPHUV,GALDAY(100),EMIN
      COMMON/PLT1/IUNIT,JLEFT
      COMMON/SURF1/UGS,VGS,COR,TAMS,TAIR,DTDX,DTDY,V10,VST,ANG,DPHI,KU
      COMMON/TESTS/TEST1,TEST2,TEST3,TEST4,TEST5,TEST6,TEST7
      COMMON/WND1/MAXST,N6HR,WXX,WYY,NPUNCH
      DIMENSION ITIME(8),ICYCLT(4),GAL6H(100)
      LOGICAL TEST1,TEST2,TEST3,TEST4,TEST5,TEST6,TEST7
      EQUIVALENCE (GALDAY(1),GAL6H(1))
      INTEGER*2 JPL
      REAL*16 LSTAT
      INTEGER $BSN
      DEFINE FILE  9(12000,80,E,$BSN)
C
C        READ IN THE INITIALIZING DATA
      WRITE(12,100)
 100  FORMAT(1X54HCOSMOS, THE 'COMPOSITE OIL SPILL MODEL FOR OPERATIONAL
     125H SERVICES', IS AT WORK.    )
C        READ IN THE OPTION FIELD
      WRITE(12,200)
 200  FORMAT(1X,79(1H*), /,1X,26HREAD IN THE FIRST DATA CARD.,/,1X,
     1  59H-   2   3   4   5   6   7   8   9 10 11 12 W.NO W.EA S.TR D.FX D.AN,
     110H T.AS J123)
      READ(5,300)ID1,ID2,ID3,ID4,ID5,ID6,ID7,ID8,ID9,ID10,ID11,ID12,
     1WSNORT,WSEAST,STRTCH,DFAX,DANG,TAMS,JD1,JD2,JD3
 300  FORMAT(12I3,6F5.2,3I1)
      WRITE(12,400)ID1,ID2,ID3,ID4,ID5,ID6,ID7,ID8,ID9,ID10,ID11,ID12,
     1WSNORT,WSEAST,STRTCH,DFAX,DANG,TAMS,JD1,JD2,JD3
 400  FORMAT(1X,I1,11I3,6F5.2,I3,2I1)
      LEVEL=ID1
      IRES=MAX0(1,MIN0(ID2,14))
      JLEFT=ID4
      CALL GRIDCO(ID5)
      IF(ID6+ID7.GT.0) JSHIFT=100*ID6+ID7
      IF(ID8.GT.0)JTMAX=ID8
      INTLOC =MAX0(5,ID9)
      IF(LEVEL.EQ.0.OR.LEVEL.EQ.3)INTLOC=1
      DFACT=DFAX*.01
      IF(JD1.EQ.1)TEST1=.TRUE.
      IF(JD2.EQ.1)TEST2=.TRUE.
      IF(JD3.EQ.1)TEST3=.TRUE.
```

```
C
C        READ IN SPILL LAT AND LONG, AND CONVERT TO NMC MODEL GRID NUMS
      WRITE(12,500)
  500 FORMAT(/,1X,28HREAD IN THE SECOND DATA CARD,/,1X,10(7H     .   ))
      READ(5,600)((PLAT(I),PLON(I)),I=1,INTLOC)
  600 FORMAT(10F7.2)
      WRITE 12,700)((PLAT(I),PLON(I)),I=1,INTLOC)
  700 FORMAT(F8.2,9F7.2)
      SLAT=PLAT(1)
      SLON=PLON(1)
      IF(LEVEL.EQ.0)GOTO2700
C
C        IF NECESSARY, READ WATER VELOCITIES
      IF(ID10.EQ.0)GOTO1100
      WRITE(12,800)
  800 FORMAT(/,1X,41HREAD IN ADDITIONAL WATER SURF. VELOCITIES)
      READ(15,900)(WNO(J),J=1,9)
      READ(15,900)(WEA(J),J=1,9)
      WRITE(12,1000)(WNO(J),J=1,9)
      WRITE(12,1000)(WEA(J),J=1,9)
  900 FORMAT(10F7.2)
 1000 FORMAT(1X,9F7.2)
 1100 CONTINUE
C
C        READ IN AUGMENTING WIND DATA
      IF(ID11.EQ.0)GOTO1400
      WRITE(12,1200)
 1200 FORMAT(/,1X,26HREAD IN THE WIND FORECASTS)
      READ(25,900)(AD10(J),J=1,9)
      READ(25,900)(APHI(J),J=1,9)
      DO 1300 J=1,9
 1300 AV10(J)=AD10(J)*1852./3600.
      WRITE(12,1000)(AD10(J),J=1,9)
      WRITE(12,1000)(APHI(J),J=1,9)
 1400 CONTINUE
C
C        READ IN OIL FLOW RATES
      IF(LEVEL.NE.3)GOTO1700
      READ(35,300)MAXST,IGAL6H
      WRITE(12,1500)MAXST,IGAL6H
 1500 FORMAT(/,1X26HREAD IN MAXST AND IGAL6H =,2I5)
      IF(IGAL6H.LE.0)GOTO1700
      READ(35,600)(GAL6H(I),I=1,IGAL6H)
      WRITE(12,1000)(GAL6H(I),I=1,IGAL6H)
      DO 1600 I=1,IGAL6H
 1600 GAL6H(I)=GAL6H(I)*1000.
 1700 CONTINUE
      WRITE(12,1800)
 1800 FORMAT(   1X,79(1H*))
C
C        CHOOSE EITHER THE 00Z OR THE 12Z CYCLE. W3FQ02 RETURNS GREEN-
C        WICH TIME FOR SUITLAND, MD.
      CALL W3FQ02(ITIME,ICYCLT)
      IZZ=1 ITIME(5)/(1700)
      IF(ID12.EQ.1)IZZ=3-IZZ
C        FIND THE NMC MODEL COORDINATES
      CALL LAT2XY(SLAT,SLON,XPOINT,YPOINT)
      WRITE(12,1900)SLAT,SLON
 1900 FORMAT(/1X26HWIND FORECAST AT LATITUDE=,F6.2,5X,10HLONGITUDE=F6.2)
      NC=YPOINT
      MC=XPOINT
      IF(TEST1) WRITE(6,2000)XPOINT,YPOINT,NC,MC
 2000 FORMAT(/,5X,'X=',F5.2,3Y,'Y=',F5.2,5X,'NC=',I2,3X,'MC=',I2,/)
C
C        MAKE THE WIND COMPUTATIONS HERE
      IF(ID11.GT.0.AND.LEVEL.LE.2)GOTO2200
      JU=0
      DO 2100 JTIME=1,JTMAX,6
      J=(JTIME-1)/6+1
      JU=JU+1
      CALL FILES
      CALL GWIND
```

```
      IF(ID11.EQ.2.AND.LEVEL.EQ.3)GOTO2100
      CALL RILIN
      KU=JU
      CALL FLMOD
      IF(ID11.EQ.1.AND.LEVEL.EQ.3)V10=AV10(J)
      IF(ID11.EQ.1.AND.LEVEL.EQ.3)DPHI=DPHI-APHI(J)
      AV10(J)=V10
      AD10(J)=V10*3600./1852.
      APHI(J)=-DPHI
      IF(APHI(J).LT.0.) APHI(J)=360.+APHI(J)
 2100 CONTINUE
 2200 CONTINUE
C
C         PRINT OUT THE PRINCIPAL RESULTS
      WRITE(12,2300)
 2300 FORMAT(/1X,5HHR(Z),3X,18HWIND SPEED AT 10 M,3X,14HTO ANGLE (DEG),/
     1,9X,5H(M/S),8X,5H(KTS),3X,17H(+C.W. FROM EAST))
      JX=JTMAX/6+1
      K=12*(IZZ-1)
      DO 2500 J=1,JX
      WRITE(12,2400)K,AV10(J),AD10(J),APHI(J)
 2400 FORMAT(3X,I2,4X,F4.1,9X,F4.1,4X,F4.0)
      K=K+6
      IF(K.GE.24) K=K-24
 2500 CONTINUE
      DO 2600 I=1,80
      DO 2600 J=1,80
      JPL(I,J)=0
 2600 CONTINUE
 2700 CONTINUE
C
C         IMPLEMENT THE OIL SPILL BEHAVIOR MODEL
      IF(LEVEL.EQ.1)GOTO3000
      CALL GEOGRY
      IF(LEVEL.EQ.0)GOTO2800
      IF(LEVEL.EQ.3)GOTO2900
      CALL DRIFT1
      GO TO 3000
 2800 CONTINUE
      CALL PLOTD1
      GOTO 3000
 2900 CONTINUE
      CALL CBASIN
      CALL OILSET
 3000 CONTINUE
      WRITE(12,3100)
 3100 FORMAT(1X17HEND OF COSMOS RUN)
      STOP
      END
//LKED.SYSLMOD DD DSN=W.NWS.SDO.TDL.KH.LOAD.H2D(KHCOS1A),DISP=SHR
//
```