VOLUME I

MODELING ADDENDUM
Permit Number AO29-173310

Long Range Transport Analysis for Class I Increment Impacts on the Chassahowitzka Wilderness Area

Gulf Coast Recycling, Inc.
Tampa, Florida

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Project 9405

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I. SUMMARY

Jim Clary & Associates was contracted by Lake Engineering to perform a Long Range Transport analysis on the Gulf Coast Recycling, Inc. facility (project) near Tampa, Florida. The purpose is to determine whether project SO2 emissions cause or contribute to modeled concentrations in excess of the PSD Class I increments. Previous Level 1 analysis by Lake Engineering calculated that project emissions exceeded the National Park Service's significant impact levels (NPS SIL) at the Chassahowitzka Wilderness Area (CWA).

This report describes the Level 2 analysis using the MESOPUFF II model in accordance with Florida Department of Environmental Protection (DEP) guidance. Additional references include the "Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 1 Report: Interim Recommendation for Modeling Long Range Transport and Impacts on Regional Visibility" (4/93), "A Modeling Protocol for Applying MESOPUFF II to Log Range Transport Problems" (10/92), and "User's Guide to the MESOPUFF II Model and Related Processor Programs" (4/84).

These Level 2 modeling results demonstrate that impacts due to project emissions may exceed the NPS SIL at the CWA, but do not cause or contribute to concentrations in excess of the Class I increments. While IWAQM guidance allows for SO2 conversion and wet/dry deposition removal for emissions from all sources, this analysis conservatively applies SO2 conversion and dry deposition removal only to the Gulf Coast emissions. Therefore, as discussed in the IWAQM, the SO2 concentrations are overestimated for the total impact from all sources. Additionally, wet removal in Florida will significantly reduce SO2 impacts at long range. The next level of modeling refinement including these processes is not required due to the low impacts provided in the summary table.

Since the highest impacts predicted in the Level I analysis occur in 1986, meteorological data for three surface stations (Tampa, Gainsville, Orlando) and one upper air station (Tampa) for 1986 were obtained and processed to represent regional air flow. Based on 1986 results, no additional years are modeled. Any additional analysis for longer data periods should not result in variations which would change the conclusion that the project does not cause or contribute to concentrations in excess of the PSD Class I increments at the CWA.

Summary of Results (micrograms per cubic meter)

Gulf Coast Recycling, Inc. Only

Averaging Period	Max Impact (ug/m3)*	NPS SIL (ug/m3)	Exceeds NPS SIL?
Annual	0.030	0.025	YES
24-Hour	0.47	0.07	YES
3-Hour	1.96	0.48	YES

* SO2 conversion and dry deposition removal. No wet deposition removal.

All DEP Inventory PSD Increment Sources (138 including Gulf Coast)

Averaging Period	Max Impact (ug/m3)**	Class I (ug/m3)	Exceeds Class I?
Annual	-0.8	2	NO
24-Hour	<1.0	5	NO
3-Hour	<10.0	25	NO

** No SO2 conversion, dry deposition removal, or wet deposition removal.

II. APPLICABLE REGULATIONS

PSD Class I Increment Standards. The facility is a major source of SO2 under PSD regulations. Long Range Transport analysis is required under an interagency agreement by the Florida DEP to address potential impacts on the Chassahowitzka Wilderness Area. This Class I area is greater than 50 kilometers north from the Gulf Coast Recycling, Inc. facility. The National Park Service has recommended significant impact levels (SIL) of 0.025, 0.07 and 0.48 ug/m3 be applied to Class I areas for the annual, 24-hour and 3-hour impacts from PSD projects. The PSD Class I increment must be evaluated for all DEP inventory increment consuming sources. PSD Class I increments are 2, 5 and 25 ug/m3 for annual, 24-hour and 3-hour average impacts.

Other State and Federal Standards. Any other applicable standards are not addressed in this report.

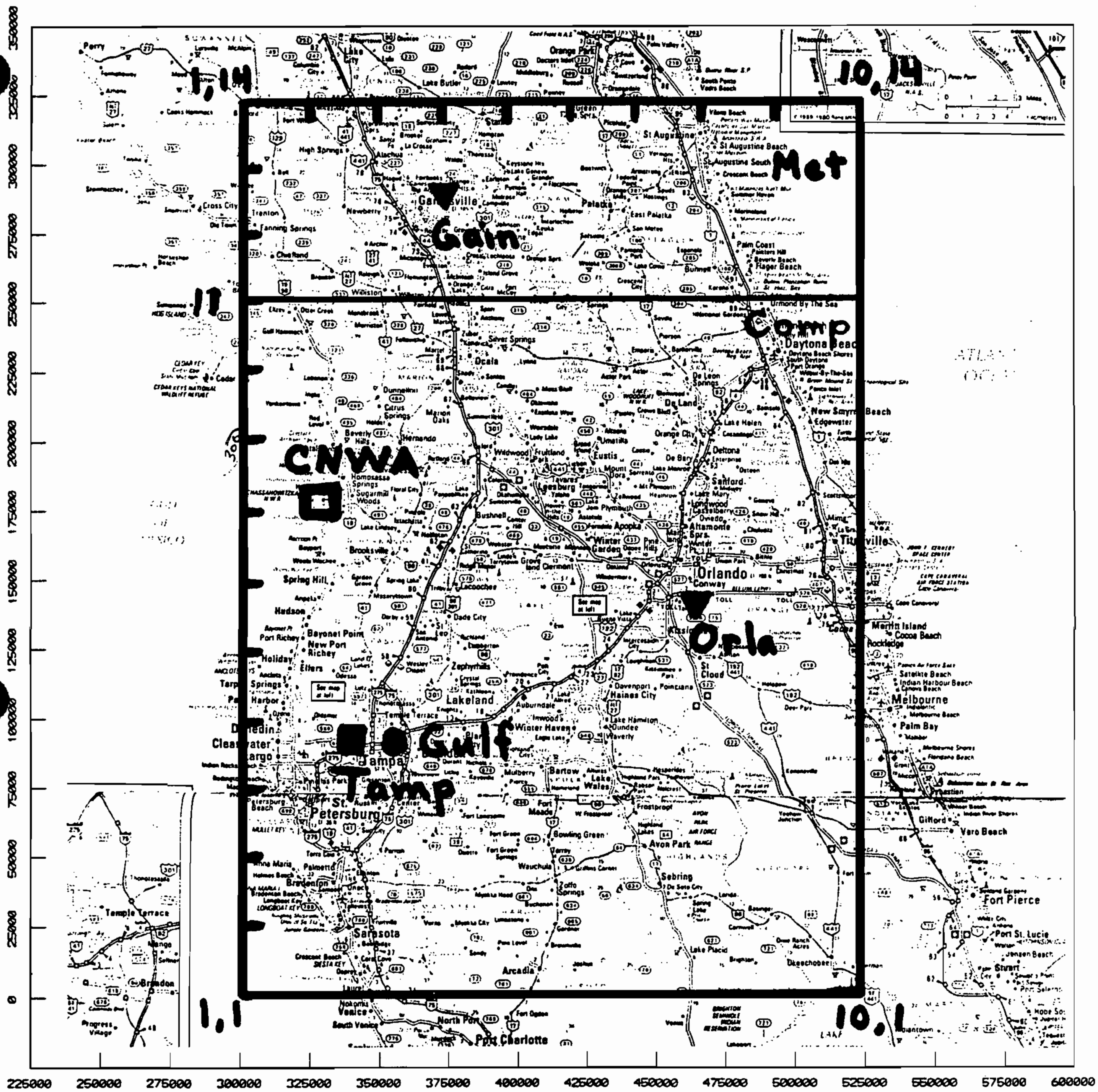
III. Project Information

A. SITE DESCRIPTION

The Gulf Coast Recycling, Inc. facility is located in Tampa, Florida. The area is near sea level on the west coast of the relatively flat Florida peninsula. Low coastal grasses, swamps and marshes, and some inland trees cover the region. For purposes of long range transport, the property boundary, building dimensions and other site plan information are not relevant. A general map of the area is provided in Figure 1 with the location of the three surface meteorological stations at Tampa, Gainsville, and Orlando identified. Additionally, as discussed in a later section, the "meteorological" and "computational" grids are shown.

B. SOURCE INVENTORY

The source inventory was provided to Jim Clary & Associates by Lake Engineering. The DEP provided the source inventory to Lake Engineering. JCA extracted the source data from the ISCST2 input file provided by Lake. The Gulf Coast Recycling, Inc. stack and emissions data were included in the same ISCST2 file. A total of 138 SO_2 increment consuming sources, including the Gulf Coast source, are analyzed. The source parameters are listed in the computer printouts in Volume II. The source locations are identified in Figure 2 as asterisks. Gulf Coast is identified as a star east of Tampa. The 13 Class I receptors provided by the Florida DEP are shown as solid dots north of Tampa.



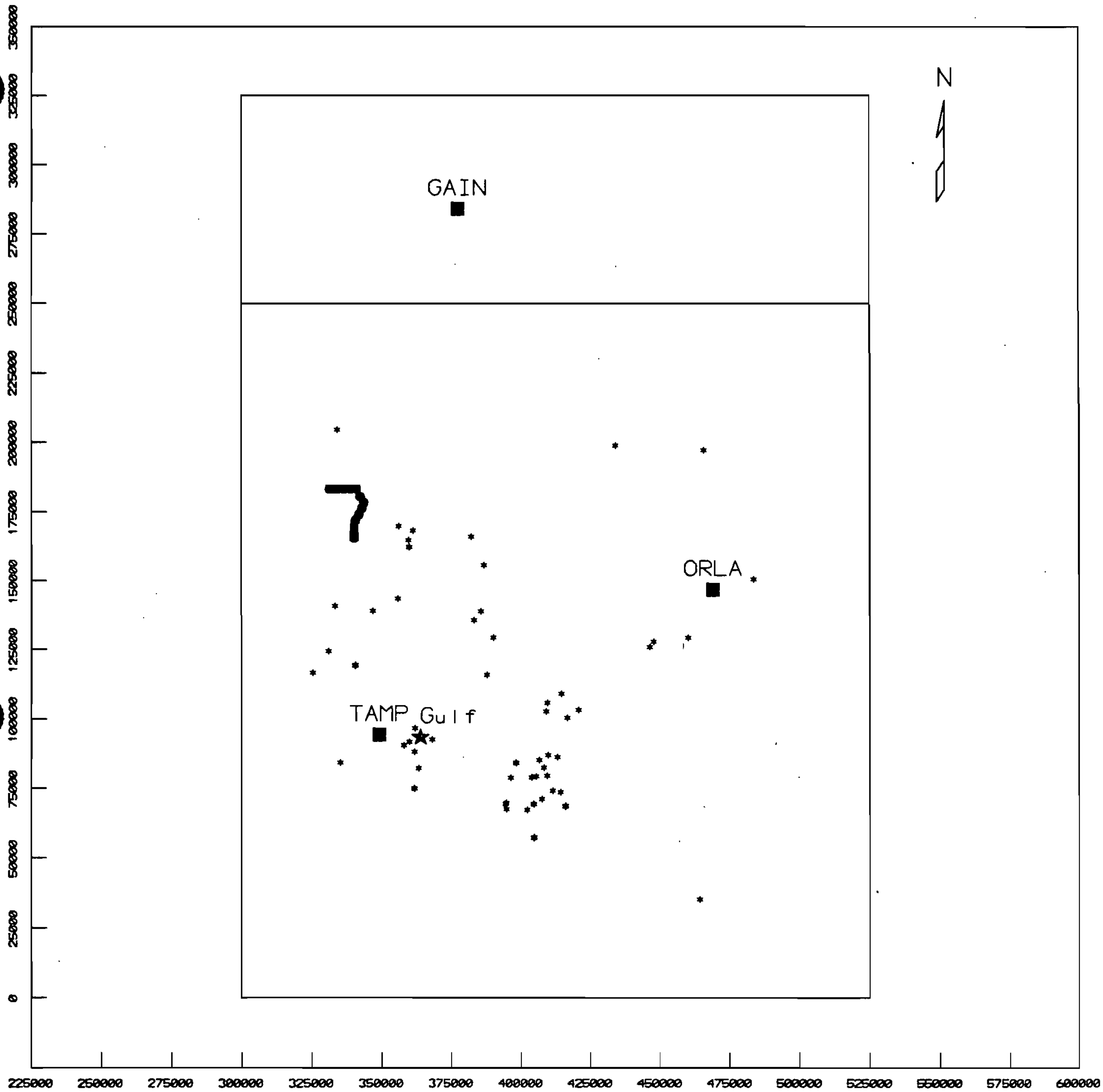
Gulf Coast Recycling, Inc.

UTM coordinates in meters

N

Met grid origin (1,1)
at UTM 300,000 m-E,
and UTM 3,000,000 m-N.
Spacing 25,000 m.

Figure 1
Area Map
Met Grid System



Gulf Coast Recycling, Inc.

UTM coordinates in meters

Star: Gulf Coast
Asterics: 137 Other
Dots: 13 Receptors
Squares: Met Site

Figure 2
Source/Receptor/
Met Locations

IV. Air Quality Review

A. MODELS AND MODELING INPUT

The MESOPUFF II model is used for all analyses in this report. MESOPUFF II is recommended in the US EPA Guideline on Air Quality Models (GAQM), revised August, 1993, for Long Range Transport applications. Additional guidance is provided in the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 1 Report (see Appendix D). The Florida DEP letter to Lake Engineering, Inc., dated September 24, 1993, identified the IWAQM as a reference document for methodology in evaluating impacts on Class I areas at distances greater than 50 kilometers. All recommended default values and settings in the IWAQM are used in this analysis, except that wet removal is not considered. MESOPUFF II is a collection of meteorological preprocessors, MESOPUFF algorithm, and a postprocessor. The precipitation preprocessors (PXTRACT, PMERGE) for assimilating data from a variety of NCDC sources and formats is not used in this analysis. Therefore, the resulting calculated SO2 impacts will be overestimated since the wet deposition removal process option is not selected. More detailed descriptions of the model are provided in the appendices of this report. A chart illustrating the modules and data flow is provided on page 3 of the User's Guide in Appendix F of this report.

READ62. This meteorological preprocessor reads a National Climate Data Center TD6201 formatted file. The program identifies missing or erroneous data which must be edited by the user and filled in before the program will execute completely for the period of record. The program is written to read an NCDC tape format. For this project, the read statements were modified by JCA to read the TD6201 provided by NCDC in diskette format. The format difference is a single record per block on disk rather than the tape format of up to 79 records per block.

MESOPAC. The meteorological preprocessor reads in all CD144 format surface stations and the output from the READ62 program for upper air data to build an array of meteorological fields for the meteorological grid identified by the user. Wind fields are constructed for two layers, within and above the boundary layer. The input data from the surface files include wind speed, wind direction, pressure, cloud cover, sky cover, temperature, precipitation type and relative humidity. The input from the upper air files include the pressure level, pressure height, wind speed and direction at level, and temperature. MESOPAC calculates according to control parameter settings in the input file constructed by the user. Recommended settings for defaults and preferred values are provided in the IWAQM in Appendix D of this report. Additional input description is provided in the protocol document and User Guide in the appendices. The output from MESOPAC is an hourly array of meteorological data for each meteorological grid cell stored as an unformatted file. This file is read by MESOPUFF to perform the advection and dispersion calculations in each computational grid cell for each hour to be analyzed. (Note that the 1986 MESOPAC unformatted file is over 50 MB and is not included with this report. It can be recreated by running MESOPAC with the provided input files on the diskettes in the appendix of this report.)

MESOPUFF. The main program which performs the advection and dispersion of emissions through the grid cells is MESOPUFF II. The model utilizes the Gaussian puff superposition approach to simulate a continuous plume. Puffs are released at user-specified intervals and tracked hourly through the grid cells over multiple user-specified periods. The model accounts for plume rise, transport, chemical transformations, dry deposition and wet removal. The model does not consider terrain or building wake effects. MESOPUFF inputs include the unformatted hourly file from MESOPAC, control parameters specified by the user, and optionally ozone data for applicable pollutants. The model outputs an unformatted file of concentrations for each hour (when using the recommended hourly averaging period) at each receptor. The user specifies the content of the output list file, typically run input verification and confirmation of successful execution. The unformatted output file is read by the MESOFILE program for averaging time calculations.

MESOFILE. The last module calculates user-specified averages on the hourly concentration file from MESOPUFF. Seven subroutines are available in the MESOFILE postprocessor for the user to specify content and format of output using the control parameter input file. MESOFILE provides an output list file of average concentrations for each averaging period. These data may be evaluated from these list files, or an additional output file is provided for further data analysis and plotting with the MESOFILE plotting routine. The user must specify to MESOFILE all functionality, which is not straightforward. Suggested input files are provided in the IWAQM and other related references to assist in identifying the desired output setup.

B. METEOROLOGICAL DATA

The meteorological data required for MESOPUFF analyses include the surface, upper air and precipitation data for all nearby stations. For this analysis, precipitation data is not required since wet removal is not considered as a conservative approach to reduce the amount of data to be purchased and processed. Three surface stations are identified as influencing the air flow regime. As seen in Figure 2, sources are located near Tampa, Orlando and north towards Gainsville. The surface data for these stations are processed in this analysis. The National Climate Data Center (NCDC) provides data at a cost of about $500 for one station year.

Independently, the U. S. EPA has contracted with NCDC to provide hourly surface data for the primary surface stations in the U. S. for use in dispersion modeling analyses. The agreement is for extraction of only the surface parameters required as input to the RAMMET meteorological preprocessor for the straight-line guideline models. Three parameters -- surface pressure, relative humidity, and precipitation type -- used in MESOPUFF are not included in the EPA surface files readily available on the SCRAM electronic bulletin board. By selecting not to evaluate wet removal, the precipitation type is not required. Therefore, the only missing parameters required for this analysis which are not in the SCRAM surface data are station pressure and relative humidity. JCA substituted representative values for station pressure (1000 mb) and relative humidity (80%) to allow the MESOPAC preprocessor to run on CD144 expanded SCRAM files. Since the files were previously quality checked for EPA modeling applications before placement on SCRAM, MESOPAC found no missing or erroneous data in the files.

The twice daily (00Z and 12Z GMT) upper air soundings were purchased from NCDC for the Tampa upper air station (Note: upper air data is not the same as the twice daily mixing height files on SCRAM generated by NCDC for EPA). These data are processed with READ62 to identify missing or erroneous values. The User's Guide, Protocol and IWAQM discuss the procedure for correcting or substituting values. The 1986 Tampa upper air data was corrected using iteration and substitution within the same year due to the short periods of missing data. After successful processing with READ62, the upper data is processed in MESOPAC up to the recommended cutoff level of 700 mb.

C. MODELING METHODOLOGY

The MESOPUFF II modeling is performed in accordance with the Florida DEP letter to Lake Engineering, IWAQM recommendations, previously published Protocol, and User's Guide. Portions of the latter three documents are provided as appendices to this report. The DEP requested that all 138 sources be modeled with MESOPUFF II for total increment consumption at the Class I area. If a Class I increment level is exceeded at any receptor for any averaging period, then it should be determined if the Gulf Coast project emissions alone contribute to the modeled violation. For all periods when the Gulf Coast project does not contribute to the violation, those impacts are not considered for evaluating the compliance of the project with the PSD standards. The IWAQM allows for SO2 conversion, dry deposition and wet removal processes. Each of these processes reduce ambient concentrations of SO2.

For this analysis, the total impacts for all sources are modeled conservatively for SO2 impacts at the Class I area by not applying SO2 conversion, dry deposition or wet removal. After completing the total impact calculations for all sources, the Gulf Coast project emissions alone are modeled for impacts at the Class I area for all averaging periods. Since no additional input data is required, these impacts are calculated using the IWAQM recommended SO2 conversion and dry deposition. The Gulf Coast impacts are compared to the National Park Service's recommended significant impact levels (NPS SIL) of 0.025, 0.07, and 0.48 ug/m3 for annual, 24-hour, and 3-hour averages. A table is created identifying the periods of highest impacts from all sources with notation whether the Gulf Coast project is significant (i.e., higher than the NPS SIL) for any period exceeding the PSD Class I standard. For this analysis, the table includes all periods with total impacts from all sources more than 1 ug/m3 for 24-hour averages and 10 ug/m3 for 3-hour averages. With PSD Class I standards of 5 ug/m3 for 24-hour and 25 ug/m3 for 3-hour averages, if the Gulf Coast emissions do not contribute to total impacts less than half of the Class I standards, then additional analysis of longer periods of data should not identify yearly variations which would threaten the Class I area.

The following subsections discuss unique modeling considerations for the Gulf Coast only impacts, and the total impacts for all 138 sources.

Gulf Coast Only for NPS SIL. The Gulf Coast project emissions are run on the full year of MESOPAC data in one run. With only one source and the 13 DEP designated receptors, the full-year run has reasonable run time and output file sizes. The SO2 conversion and dry deposition options are used in accordance with IWAQM settings.

All Sources for PSD Class I Increment. All 138 inventory sources provided by the Florida DEP are modeled for PSD Class I increment consumption at the 13 designated receptors. The Gulf Coast project emissions are included in the inventory. The run times on these sources are quite long producing very large list and unformatted output files. Therefore, the impacts for all sources are run in separate monthly runs. The beginning day specified in each MESOPUFF run is four days prior to the first day of the month to allow for the puffs to travel through the grid prior to the first valid average calculation. The results of the four days from the previous month are not extracted with MESOFILE. Annual averages are calculated at each receptor by calculating the monthly average for each month. Then each monthly average is multiplied by the number of hours in the month to obtain the total monthly sum. The monthly sums are summed, then divided by the total number of hours in the year. These calculations are performed in a spreadsheet. The monthly results for the 24-hour and 3-hour averages are calculated easily with MESOFILE since these averaging periods are within the period of computation.

D. GRIDS

The MESOPUFF II model requires the user to define two grid systems, and optionally a third. Required are the "meteorological" and "computational" grids. Optionally, a "sampling' grid may be identified if the model is used to generate a receptor grid. For this analysis, only discrete receptors as provided by the DEP are required, therefore a sampling grid is not needed.

Meteorological Grid. The meteorological grid is the key grid to be defined. All locations in the model inputs are specified in the coordinates of this grid. By convention, MESOPUFF defines the lower left corner of the meteorological grid as coordinate (1,1). The grid increases in x values to the east and y values to the north. A maximum of 40 grid values in each direction may be defined. The recommendation of the IWAQM is that the spatial resolution be determined by the distance between meteorological observation stations. The maximum recommended spacing is 1/3 the median distance between observing stations. It is noted that finer resolutions may be used with increased computation times and no improvement in results. The meteorological grid should extend to include the locations of all observation stations. As shown in Figures 1 and 2, the meteorological grid encompasses Tampa, Gainsville and Orlando. The distance between Tampa and Orlando is approximately 125,000 meters, allowing for a maximum resolution of about 40,000 meters. For this analysis, a resolution of 25,000 meters is selected. Beginning the meteorological grid at UTM coordinates (300,000 m-E and 3,000,000 m-N) for the origin set equal to grid coordinate (1,1), the grid is extended east 9 grid units to UTM 525,000 m-E, and north 13 grid units to UTM 3,325,000 m-N. This grid includes all sources, meteorological observation stations, and the Class I area.

Computational Grid. The computational grid must be a subset of the meteorological grid, though it may be defined as the same grid. The grid must include all sources and receptors to be evaluated. Additionally, the grid should extend at least two grid units beyond the sources and receptors to ensure that puffs which may impact from a source to a receptor are not dropped from tracking when the puff leaves the computational grid. As seen in Figure 2, all sources and receptors are within the two grid unit margin. The computational grid is defined the same as the meteorological grid in the east-west direction, but is stopped below Gainsville in the north-south direction above the last sources. The northerly extent is 10 grid spaces (250,000 m), or a grid north value of 11.

E. LAND USE CATEGORIES

The land use for each meteorological grid cell must be defined by the user as input to the MESOPAC preprocessor. The land use category is used in each cell for several purposes, including stability class determination, surface roughness, mixing length and surface heat availability. The land use for this analysis is determined using USGS 7.5 minute topographic maps with land use coding. The USGS codes are interpreted to match the MESOPUFF categories in the Protocol (see Appendix E of this report, page 26). Five applicable categories represent the land categories within the meteorological grid cells. The categories are cropland/pasture, ungrazed forest, swamp, city and ocean/lake. These categories are entered as a 10x14 array, one for each grid cell.

F. RECEPTORS

The Florida DEP provided the locations of 13 receptors representative of the Chassahowitzka Wilderness Area. The receptor locations are identified as solid dots in Figure 2. All 13 receptors are included in each MESOPUFF analysis.

G. MODELING RESULTS

The results of the modeling will are presented in the order discussed in the methodology. The results for the Gulf Coast project emissions alone on the Class I area are presented to determine if the project has a significant impact. Then, the total impact for all sources is presented to determine if the PSD Class I increment is threatened when the Gulf Coast project has a significant impact.

Volume II, Appendix A, of this report contains the computer printouts of both input and output files for the modeling runs. Also, diskettes are provided in Appendix B of Volume II.

MESOPAC Preprocessing. Since MESOPAC is a preprocessor, the results are applicable as input files for all MESOPUFF runs. No additional discussion is required. The input and output files are on diskette in Appendix B of Volume II.

Gulf Coast Only for NPS SIL. The results for Gulf Coast project emissions only are included in the runs printed in Appendix A of Volume II. The annual run (GULF86.LST) indicates a maximum impact of 0.030 ug/m3 (2.9887E-08 g/m3) at Receptor 1. The 24-hour run (GULF8624.LST) indicates a maximum impact of 0.47 ug/m3 (4.7361E-07 g/m3) occurring on Julian day 255 (Julian day ending 256, hour 0) at Receptor 1. The 3-hour run (GULF8603.LST) indicates a maximum impact of 1.96 ug/m3 (1.9577E-06 g/m3) occurring on Julian day 255, ending hour 09, at Receptor 1. Therefore, the Gulf Coast project emissions do exceed the NPS SIL at the Class I area for all three averaging periods.

All Sources for PSD Class I Increment. The results for all sources are included in the runs printed in Appendix A of Volume II. These runs are made as monthly runs to reduce individual run times and the size of intermediate unformatted files.

Annual Average Impact. The monthly runs are entitled "ALLmm", where ALL is all sources and mm is the two digit month sequence. The monthly averages are summarized in the table in Appendix A, "Annual Average Impacts." The method of calculating the annual average from these monthly averages is described in the methodology section. The highest annual average impact is -0.807 ug/m3 at Receptor 13. This value is calculated in the spreadsheet table in Appendix A from runs ALL01.LST through ALL12.LST.

24-Average Impact. For 24-hour impacts, all values higher than 1 ug/m3 are extracted from runs ALL0124.LST through ALL1224.LST. These values are listed in the table in Appendix B, "24-Hour Average Impacts." The highest average impact for all sources is 7.32 ug/m3 on Julian day 139 at Receptor 6. However, the impact from the Gulf Coast project emissions for Julian day 139 at Receptor 6 is only 0.001 ug/m3 (run GULF8624.LST), much less than the NPS SIL. In accordance with Florida DEP, IWAQM, US EPA and NPS guidance, the Gulf Coast project emissions are not significant for this impact. Following the same methodology for each value in the table of Appendix B, it is seen that the Gulf Coast project emissions are not significant on any day at any receptor when the 24-hour impact for all sources is higher than 1 ug/m3. Therefore, the maximum impact for all sources when Gulf Coast project emissions are significant is less than 1 ug/m3. The postprocessing program MESOFILE is not conducive to easily extracting the actual value.

3-Hour Average Impact. Applying the same methodology as described for the 24-hour impact, the table in Appendix C, "3-Hour Average Impacts" provides all receptor locations, days and 3-hour periods when the impact from all sources is higher than 10 ug/m3. With the PSD Class I increment standard of 25 ug/m3 for a 3-hour average, if the Gulf Coast project emissions are not significant for any of these impacts, further analysis should not be required. As seen in the table in the appendix, the highest 3-hour average impact is 21.18 ug/m3 on Julian day 333, ending hour 0, at Receptor 12. The impact from the Gulf Coast project emissions for this time at this receptor is 0.0008 ug/m3 (run GULF8603.LST). For all impacts in the table, the Gulf Coast project emissions for the same time and receptor are less than the NPS SIL. Therefore, the highest 3-hour impact for all sources when Gulf Coast is significant is less than 10 ug/m3.

H. COMPARISON WITH STANDARDS

The modeling results are compared to the National Park Service's Significant Impact Levels (NPS SIL) and the PSD Class I increments in the summary table. Based on these 1986 results, no additional years are modeled. Any additional analysis for longer data periods should not result in variations which would change the conclusion that the project does not cause or contribute to concentrations in excess of the PSD Class I increments at the Chassahowitzka Wilderness Area.

Summary of Results (ug/m3)

Gulf Coast Recycling, Inc. Only

Averaging Period	Max Impact (ug/m3)*	NPS SIL (ug/m3)	Exceeds NPS SIL?
Annual	0.030	0.025	YES
24-Hour	0.47	0.07	YES
3-Hour	1.96	0.48	YES

* SO2 conversion and dry deposition removal. No wet deposition removal.

All DEP Inventory PSD Increment Sources (138 including Gulf Coast)

Averaging Period	Max Impact (ug/m3)**	Class I (ug/m3)	Exceeds PSD Class I?
Annual	-0.8	2	NO
24-Hour	<1.0	5	NO
3-Hour	<10.0	25	NO

** No SO2 conversion, dry deposition removal, or wet deposition removal.

Volume I

Appendix A

Annual Average Impacts

Volume I

Appendix A
Annual Average Impacts

ANNUAL AVERAGING IMPACTS
(All 138 Sources)

Month	Hours in month	Receptor # 1	2	3	4	5	6	7	8	9	10	11	12	13
1	744	-0.74	-0.76	-0.80	-0.83	-0.83	-0.72	-0.67	-0.68	-0.69	-0.88	-0.93	-1.03	-1.15
2	672	-1.30	-1.28	-1.28	-1.27	-1.30	-1.36	-1.41	-1.39	-1.35	-1.29	-1.23	-1.03	-0.84
3	744	-1.47	-1.43	-1.36	-1.27	-1.06	-0.93	-0.86	-0.98	-1.12	-1.25	-1.21	-1.11	-0.98
4	720	0.57	0.51	0.43	0.37	0.29	0.21	0.13	0.04	-0.06	-0.05	0.00	0.07	0.14
5	744	1.17	1.27	1.34	1.37	1.46	1.49	1.47	1.44	1.39	1.38	1.30	1.19	1.08
6	720	-2.34	-2.26	-2.21	-2.19	-2.19	-2.19	-2.18	-2.14	-2.08	-2.04	-1.96	-1.00	-1.61
7	744	-2.14	-2.04	-1.95	-1.88	-1.82	-1.75	-1.67	-1.54	-1.38	-1.35	-1.31	-1.26	-1.20
8	744	-3.10	-2.98	-2.85	-2.68	-2.49	-2.33	-2.20	-2.13	-2.03	-2.06	-2.07	-2.04	-1.99
9	720	-0.19	-0.13	-0.10	-0.07	-0.01	0.03	0.03	0.00	0.00	-0.04	-0.10	-0.15	-0.19
10	744	-0.61	-0.57	-0.54	-0.52	-0.46	-0.41	-0.42	-0.59	-0.76	-0.86	-0.85	-0.63	-0.37
11	720	-1.06	-0.90	-0.71	-0.47	-0.21	-0.06	-0.02	-0.12	-0.27	-0.34	-0.36	-0.39	-0.53
12	743	-1.92	-2.00	-2.11	-2.26	-2.29	-2.31	-2.33	-2.50	-2.76	-2.92	-2.85	-2.47	-2.01
Total	8759	-13.13	-12.57	-12.14	-11.70	-10.91	-10.33	-10.13	-10.59	-11.11	-11.70	-11.57	-9.85	-9.65
Annual Average		-1.096	-1.049	-1.013	-0.977	-0.910	-0.860	-0.843	-0.882	-0.926	-0.976	-0.966	-0.824	-0.807

* Highest Annual Average Impact = **-0.807** ug/m^3 at Receptor 13

Appendix B
24-Hour Average Impacts

Appendix B

24-Hour Average Impacts

24 - HOUR AVERAGE IMPACTS
(All 138 Sources, 1986, H1H)
(Summary of Periods ≥ 1μg/m³)

Run ID	Impact (μg/m³)	Receptor ID	Julian Day	Gulf Coast > NPS SIL?
ALL0124.LST	2.08	1	10	NO
	4.17	1	17	NO
	4.69	7	18	NO
ALL0224.LST	4.63	5	33	NO
	4.04	2	34	NO
	4.63	1	35	NO
	2.15	5	48	NO
ALL0324.LST	1.67	13	68	NO
	4.23	7	69	NO
	3.56	1	85	NO
	3.37	1	86	NO
	1.57	1	89	NO
	1.49	1	90	NO
ALL0424.LST	3.89	3	94	NO
	7.10	***1***	***95***	***NO (0.0)***
	3.12	1	96	NO
	4.20	1	97	NO
	2.96	1	105	NO
	1.28	1	106	NO
	1.00	1	110	NO
	1.37	1	116	NO
ALL0524.LST	1.14	8	122	NO
	5.13	***3***	***126***	***NO (0.0)***
	1.89	1	129	NO
	2.09	1	131	NO
	2.52	1	132	NO
	2.89	1	133	NO
	4.15	6	134	NO
	5.97	***2***	***135***	***NO (0.001)***
	5.81	***1***	***136***	***NO (0.0)***
	4.78	1	137	NO
	3.99	1	138	NO
	7.32	***6***	***139***	***NO (0.001)***
	2.03	4	141	NO
	1.76	9	145	NO
	5.95	***9***	***146***	***NO (0.003)***

Run ID	Impact ($\mu g/m^3$)	Receptor ID	Julian Day	Gulf Coast >NPS SIL?
	3.62	6	147	NO
	3.94	6	148	NO
	2.24	7	149	NO
	3.11	10	157	NO
	2.45	9	152	NO
ALL0624.LST	3.60	1	153	NO
	1.71	1	155	NO
	3.74	1	156	NO
	2.33	6	163	NO
	4.57	3	174	NO
	6.40	2	175	NO
	2.84	4	176	NO
	1.42	1	179	NO
	2.47	1	180	NO
ALL0724.LST	3.49	1	189	NO
	5.07	***2***	***190***	***NO (0.0006)***
	1.95	9	200	NO
ALL0824.LST	4.15	5	220	NO
	3.15	5	221	NO
	2.61	7	224	NO
	4.81	1	239	NO
	6.84	***1***	***245***	***NO (0.0004)***
	5.19	***4***	***246***	***NO(0.004)***
	4.72	10	253	NO
	2.36	7	255	NO
	1.35	1	258	NO
	1.89	1	259	NO
	2.56	1	260	NO
	1.69	1	261	NO
	4.31	2	262	NO
	3.76	2	263	NO
	2.44	1	265	NO
	1.46	1	265	NO
	2.50	1	266	NO
	2.01	13	270	NO
	2.55	1	273	NO
ALL1024.LST	2.12	5	275	NO
	4.85	2	176	NO
	3.66	7	277	NO
	2.81	13	278	NO
	3.03	9	283	NO

Run ID	Impact ($\mu g/m^3$)	Receptor ID	Julian Day	Gulf Coast >NPS SIL?
ALL1024.LST	2.74	5	286	NO
	7.13	***4***	***287***	***NO (0.0)***
	1.46	8	290	NO
	2.05	1	296	NO
	4.69	1	297	NO
	4.59	7	298	NO
	3.84	2	303	NO
	3.20	1	305	NO
ALL1124.LST	3.15	1	306	NO
	3.67	5	313	NO
	3.59	1	314	NO
	4.21	4	315	NO
	1.31	7	317	NO
	3.94	1	318	NO
	1.69	1	319	NO
	1.73	1	327	NO
	5.54	***6***	***328***	***NO (0.0)***
	6.96	***7***	***329***	***NO (0.0)***
	4.77	7	330	NO
	1.20	7	334	NO
ALL1224.LST	2.00	1	342	NO
	1.28	12	344	NO
	1.58	1	349	NO
	1.01	1	357	NO

Appendix C

3-Hour Average Impacts

Appendix C
3-Hour Average Impacts

3 - HOUR AVERAGING IMPACTS
(All 138 Sources, 1986, H1H)
(Summary of Periods ≥ 10 μg/m³)

Run ID	Impact (μg/m³)	Receptor ID	Julian Day	Hour Ending	Gulf Coast > NPS SIL?
ALL6103.LST	***13.67***	***1***	***16***	***12***	***NO (0.0)***
	12.13	1	17	09	NO
ALL0203.LST	10.35	1	34	12	NO
ALL0303.LST	10.89	1	68	06	NO
	17.65	***3***	***68***	***09***	***NO (0.0)***
ALL0403.LST	10.58	1	95	00	NO
	11.78	9	95	06	NO
	11.78	1	96	03	NO
	14.09	***1***	***105***	***00***	***NO (0.0)***
	10.77	1	105	03	NO
	15.71	***1***	***110***	***09***	***NO (0.0)***
ALL0503.LST	12.40	1	134	03	NO
	10.57	2	134	09	NO
	12.39	3	134	12	NO
	10.40	3	135	09	NO
	16.44	***6***	***138***	***06***	***NO (0.0)***
	10.92	6	138	09	NO
	13.44	***7***	***138***	***12***	***NO (0.003)***
	11.43	10	145	09	NO
	13.84	***12***	***145***	***12***	***NO (0.0)***
	11.39	7	146	03	NO
	10.50	6	146	06	NO
	10.21	9	147	06	NO
	10.15	8	147	09	NO
ALL0603.LST	11.37	3	174	03	NO
	11.23	1	174	09	NO
	10.20	4	174	03	NO
ALL0703.LST	10.88	1	189	09	NO
	10.58	9	199	21	NO
ALL0803.LST	10.15	11	213	15	NO
	11.16	2	222	09	NO
	10.74	1	238	09	NO
	11.38	1	243	09	NO
ALL0903.LST	***13.76***	***1***	***244***	***09***	***NO (0.0)***
	13.14	***5***	***245***	***12***	***NO (0.0)***
	11.07	6	252	15	NO
	11.30	9	252	18	NO

Run ID	Impact (μg/m^3)	Receptor ID	Julian Day	Hour Ending	Gulf Coast >NPS SIL?
ALL1003.lst	10.99	3	275	12	NO
	11.25	7	276	12	NO
	11.92	7	281	12	NO
	12.49	***7***	***282***	***12***	***NO (0.0)***
	10.77	4	286	09	NO
	11.96	4	286	12	NO
	10.67	5	297	06	NO
ALL1103.LST	10.07	2	305	09	NO
	13.90	***12***	***325***	***12***	***NO (0.0)***
	14.73	***5***	***327***	***12***	***NO (0.0)***
	11.34	9	328	00	NO
	13.08	***9***	***328***	***03***	***NO (0.0)***
	13.68	***8***	***328***	***09***	***NO (0.0)***
	10.12	12	329	00	NO
	12.37	7	329	03	NO
	10.07	1	330	03	NO
ALL1103.LST	***21.18***	***12***	***333***	***00***	***NO (0.0008)***
	19.17	***12***	***333***	***03***	***NO (0.0001)***
	18.19	***12***	***333***	***06***	***NO (0.155)***
ALL1203.LST	10.71	13	343	03	NO
	20.49	***12***	***343***	***06***	***NO (0.002)***
	15.64	***12***	***343***	***09***	***NO (0.002)***
	11.61	13	348	12	NO
	11.11	13	357	06	NO
	10.18	13	357	09	NO

Appendix D
Extracted Sections from IWAQM Guidelines

Appendix D

Extracted Sections from IWAQM Guidelines

EPA-454/R-93-015

INTERAGENCY WORKGROUP ON AIR QUALITY MODELING (IWAQM) PHASE 1 REPORT: INTERIM RECOMMENDATION FOR MODELING LONG RANGE TRANSPORT AND IMPACTS ON REGIONAL VISIBILITY

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April 1993

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PHASE 1 RECOMMENDATION SUMMARY

Until the Phase 2 work of the IWAQM is complete the IWAQM recommends the following modeling approach be used under circumstances which require the analysis of Class I area impacts for sources more than 50 kilometers and up to several hundred kilometers away. This recommendation is interim in that certain technical compromises were made in order to satisfy the immediate need for a workable modeling approach.

I. LEVEL I ANALYSIS (PLUME MODEL)

A. PSD INCREMENT AND STANDARDS

(1) For conditions other than extended stagnation or known conditions of pollutant recirculation, a steady-state, Gaussian plume model may be used for all sources.

(2) Mass removal model options for either chemical transformation or deposition should not be employed.

(3) Where recirculation or stagnation is known to be important the applicant should use the Level II analysis only.

(4) If the Level I analysis indicates an exceedance then a complete Level II analysis should be performed.

B. VISIBILITY

The applicant should use the same approach as is described in I.A. with the following additions:

(1) Assume that all of the emitted SO_2 and NO_X has been converted to $SO_4^=$ and NO_3^- respectively.

(2) The concentrations of $SO_4^=$ and NO_3^- should then be used in conjunction with the techniques presented in Appendix B to estimate impacts on Class I area visibility.

C. OTHER AQRVs

The applicant should use the same approach as is described in I.A. with the following additions:

(1) Assume that all of the emitted SO_2 remains as SO_2 and that the NO_X has been converted to HNO_3.

(2) Use appropriate deposition velocities to estimate the deposition of the pollutants. (See Inset 2.)

II. LEVEL II ANALYSIS (MESOPUFF-II)

A. PSD INCREMENT AND STANDARDS

(1) For sources > 50 km (and up to several hundred km) from <u>all</u> Class I area receptors MESOPUFF-II should be used.

(2) For sources ≤ 50 km from <u>all</u> Class I area receptors, models recommended for use in the EPA Modeling Guideline should be used.

(3) For those sources located such that some Class I receptors are ≤ 50 km and others are > 50 km the applicant may either

(a) model all receptors with a Guideline model, or

(b) model those receptors which are > 50 km with MESOPUFF-II and those which are ≤ 50 km with a Guideline model.

(4) Concentrations from all sources should be summed hour-by-hour, receptor-by-receptor and pollutant-by-pollutant.

B. VISIBILITY

(1) All sources being analyzed, regardless of their distance from the Class I area, should be modeled with MESOPUFF-II following the procedures set forth in Appendix A.

(2) Using the predicted concentrations of $SO_4^=$ and NO_3^-, regional haze calculations should be made in accordance with the procedures set forth in Appendix B.

(3) If it is determined that plume blight analyses need to be made, the recommendations regarding use of VISCREEN and PLUVUE II in the *Guideline on Air Quality Models (Revised)* should be followed.

C. OTHER AQRVs (Depositional Loading)

(1) All sources being analyzed, regardless of their distance from the Class I area, should be modeled with MESOPUFF-II following the procedures set forth in Appendix A.

(2) Outputs of $SO_4^=$ and NO_3^- deposition should be used, as necessary, to quantify the impact to aquatic and terrestrial ecosystems. Close coordination with the Federal Land Manager will be necessary in determining the appropriate averaging times for this analysis.

III. MESOPUFF-II

The following applies to all applications of MESOPUFF II within the context of the Phase 1 recommendation.

A. Follow the recommendations found in Appendix A.

B. The cross over distance for the time dependent dispersion curves should be set to 10 km.

C. Both wet and dry deposition options should be employed.

D. The model's chemical transformation algorithms should be employed.

IV. METEOROLOGY

A. PERIOD OF RECORD (Applies to both MESOPUFF-II and Guideline models)

(1) A five year National Weather Service (NWS) meteorological data record should be used when the applicant source is either > 50 km from the Class I area or is within 50 km and does not have at least one year of on-site data.

(2) For an applicant source located within 50 km of a Class I area, all sources being modeled should use a representative data record which corresponds to the time period of the on-site data. On-site data can not be used unless it covers at least one full year. Furthermore, if more than one year of on-site data exists it should be used up to the most recent 5 years.

B. SELECTION OF DATA BASES

(1) GUIDELINE MODEL: It may be desirable to divide the analysis domain into meteorologically similar areas and use area specific representative meteorological data to model all sources' impacts in that area. The use of multiple meteorological data bases is not the normal practice with Guideline models and should be approved on a case-by-case basis by the appropriate regulatory authority.

(2) MESOPUFF-II: The number and location of the NWS meteorological data bases to be used in the MESOPUFF-II analysis should be determined on a case-by-case basis, generally using all available, <u>representative</u> data.

Appendix A

IWAQM Recommendations for Running The MESOPUFF-II Modeling System

grid, since once puffs leave the grid, they are eliminated from the computations; concentrations may be significantly underestimated for sources or receptors too close to the edge of the computational grid.

Spatial Resolution

The various grid systems used in the MESOPUFF-II modeling system are all relative to the initially defined meteorological grid. Therefore, the resolution (grid spacing) of the meteorological grid is of prime importance. Since the meteorological fields, generated by the MESOPAC processor, are defined from the interpolation of available observations, the practical resolution of those fields will depend on the distance between observation stations. Therefore, the maximum recommended resolution is $\frac{1}{3}$ the median distance between observation stations. Finer resolutions can be used, but at the cost of some computation time. If an area in the domain is considered very important and has relatively dense meteorological observations, then the resolution should be based on this area of more refined observations.

In general, all available meteorological stations within the initially defined grid system should be included in the analysis. Stations relatively near to the boundaries, particularly upper air stations, should also be included, as they will improve the representativeness of the wind fields generated by the interpolation.

Temporal Scale

In order to capture year-to-year meteorological variability and the effect that can have on air pollution concentrations, five years of meteorological data should be run with the MESOPUFF-II modeling system.

Precipitation and Upper Air Meteorological Processors

The version of MESOPAC, the meteorological processor for the MESOPUFF-II modeling system, being distributed, can make use of upper-air meteorological data in either a TD-5600 format or the newer TD-6201 format. Processors for both of these data types are provided with the modeling system. Precipitation data is now distributed in a TD-3240 format. Descriptions and information on running these processors are provided below.

Card Group 6 - DEFAULT OVERRIDE OPTIONS				
Columns	**Typ***	**Var Name**	**Description**	**Recommended Value**
1	IAE	iopts(1)	Use Default Surface Wind Speed Measurement Height (Default=10m)	0
2	IAE	iopts(2)	Use Default von Karman Constant (Default=0.4)	0
3	IAE	iopts(3)	Use Default Friction Velocity Constants (Defaults: γ=4.7, A=1100)	0
4	IAE	iopts(4)	Use Default Mixing Height Constants (Defaults: B=1.41, E=0.15, Δz=200m, $\partial\theta/\partial z_{min}$=0.001°K/m, N=2400	0
5	IAE	iopts(5)	Use Default Wind Field Variables (Defaults: Vertically Averaged Winds used from Ground to Mixing Height, Vertically Averaged Winds used from Mixing Height to 700 mb, & Scan Radius for Wind Field Interpolation RADIUS=99.0km)	0
6	IAE	iopts(6)	Use Default Surface Roughness Lengths (Determined from Land Use Categories)	0
7	IAE	iopts(7)	Use Default Heat Flux Estimates (Can not be changed)	0
8	IAE	iopts(8)	Use Default Radiation Reduction Factors (Defaults: 1.0, 0.91, 0.84, 0.79, 0.75, 0.72, 0.68, 0.62, 0.53, 0.41, 0.23	0
9	IAE	iopts(9)	Use Default Heat Flux Constants (Default: RADC=0.3)	0
10	IAE	iopts(10)	If iopts(10)=1, starting date of run is <u>not</u> the beginning of the meteorological file, else set iopts(10)=0	0 or 1 as appropriate

Card Group 5 - TECHNICAL OPTIONS				
Columns	**Typ***	**Variable Name**	**Description**	**Recommended Value**
1-5	L	lgauss	Vertical Distribution control (F=uniform, T=Gaussian)	T
6-10	L	lchem	Chemical transformation control	T
11-15	L	ldry	Dry deposition control	T
16-20	L	lwet	Wet removal control	T
21-25	L	l3vl	Dry removal from surface layer (T) or throughout mixed layer (F)	T

Card Group 7				
Columns	**Typ***	**Variable Name**	**Description**	**Recommended Value**
1	IAE	iopts(1)	Use default dispersion parameters (a_y, b_y, a_z, b_z, a_{zt} as defined by Turner and Heffter, T_m=10000, jsup=5 (T_m reset in code from original default value of 100000)	0
2	IAE	iopts(2)	Use default vertical diffusivity constants k_1=0.01, k_2=0.10	0
3	IAE	iopts(3)	Use default SO_2 canopy resistance	0
4	IAE	iopts(4)	Use default dry deposition parameters	0
5	IAE	iopts(5)	Use default wet removal parameters	0
6	IAE	iopts(6)	Use default chemical transformation methods	0

Appendix E

A Modeling Protocol for Applying MESOPUFF II
to Long Range Transport Problems

Appendix E

A Modeling Protocol for Applying MESOPUFF II
to Long Range Transport Problems

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park, NC 27711

EPA-454/R-92-021
October 1992

AIR

EPA

A MODELING PROTOCOL FOR APPLYING MESOPUFF II TO LONG RANGE TRANSPORT PROBLEMS

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3.0 RECOMMENDED PROCEDURES FOR APPLYING MESOPUFF II

This chapter describes recommended procedures for applying MESOPUFF II and its preprocessors to regulatory problems associated with the long range transport of relatively inert pollutants such as SO_2 or particulate matter. As noted earlier, the procedures recommended in this protocol are most applicable to regulatory problems involving PSD or other SIP related analyses. These recommendations are general in nature, and have been developed to foster consistency in applying MESOPUFF II to problems of these types. They have evolved primarily from results obtained from conducting model performance evaluations and sensitivity analyses, and have been developed to be as consistent as possible with general modeling concepts expressed in "Guideline on Air Quality Models".[3] It is recognized, however, that deviations from these procedures may be warranted in some situations, but in such instances they should be clearly documented and fully supportable.

The discussion that follows is divided into five broad categories: 1) the spatial and temporal scales of an analysis, 2) the compilation of a meteorological data base, 3) application of the MESOPUFF II preprocessors, 4) application of MESOPUFF II, and 5) control strategy evaluation. Each topic is discussed in general terms, with recommended procedures summarized in a single-spaced format. The discussions that follow are limited, however, to describing procedures for developing model inputs and to identifying preferred model options to be used in regulatory applications. Specific operational aspects of the model and its preprocessors and the formats for coding the model inputs are described in reference 2.

downwind of the source, no need exists to use a grid system that extends up to 400km downwind of the source. Nevertheless, sources and receptors should not be located too near the boundary of the computational grid to avoid possible boundary effects.[2] A cushion of two to three grid points around the edges of the sources and impact areas should be adequate.

Recommended Procedure. MESOPUFF II can be used to estimate source impacts at distances 50 to 400km downwind. The meteorological and computational grid systems used to define the modeling region should be formulated so as to encompass all sources and impact areas, with neither being located too near the edge of the computational grid. Grid dimensions that greatly exceed 1000km in the west-east direction or 600km in the south-north direction are not recommended. Finally, spacing of the meteorological grid on the order of 10 to 50km will probably be adequate for most applications, depending on the overall grid size and relative spacing between meteorological stations.

3.1.2 Temporal Scale

The second portion of this section deals with the time frames for conducting the modeling analyses. As described in Section 2.1, PSD and SIP regulatory analyses typically involve estimating source impacts for both short-term (e.g., 3-hour and 24-hour) and long-term (e.g., annual) averaging periods. Further, MESOPUFF II is oriented towards evaluating short-term impacts, i.e., it operates on hourly meteorological data and predicts ambient concentrations at hourly intervals from which concentrations for longer averaging periods can be computed. As discussed in Section 2.1, procedures do not currently exist for identifying critical short-term periods *a priori* (i.e., selecting those short-term periods with the highest and second-highest concentrations without running the model for a full year). Thus, it is recommended that the model be applied for a minimum period of record of one full year. From such an annual simulation, both the short and long-term critical concentrations can be determined. The minimum 1-year recommendation is made recognizing that computational expense and data availability may prohibit the routine application of the model to a longer period of record.

In making the recommendation to model a complete year, it is recognized that computer limitations may preclude completing an annual simulation in a single model run. Model simulations can be conducted for shorter time periods, however, and the results concatenated to produce concentration estimates for a complete year. As described in the next chapter, the annual simulation for the example problem was developed by performing 12 individual monthly simulations. When this procedure is used, it will be necessary to set the simulation starting day at least four days prior to the actual period of interest in order to account for initial transport and dispersion. The modeling results for the first four days would then be discarded. For example, a simulation for the month of June would have a starting day of May 28, and the model predictions for May 28 through May 31 would be ignored. In order to avoid having to obtain two years of meteorological data to follow this procedure for the beginning of the year, the starting point of the annual simulation could be January 1 (as opposed to December 28 of the preceding calendar year).

Recommended Procedure. For regulatory applications of MESOPUFF II, it is recommended that a minimum one year period of record be simulated in order to identify the critical short- and long-term impacts. Computational limitations will likely necessitate that full annual simulations be obtained by performing a series of simulations for shorter time periods (e.g., monthly periods) and concatenating the model predictions. In such cases, the starting point for the shorter simulations should be set to four days prior to the start day for the period being modeled, and the model predictions for these first four days be discarded. It is not necessary to follow this procedure for the start of the annual period however.

in Section 3.4, including wet removal in regulatory applications is not currently recommended. Thus, for the applications discussed here, it is not necessary to obtain or process these data.

Recommended Procedure. Upper air and hourly surface data from as many stations as possible that are located within the modeling domain should be included in the modeling simulations. It is recommended that the year of record be chosen on the basis of maximum meteorological data availability. Both upper air and surface data sets should be screened and edited so as to provide complete data sets for the period of record to be modeled.

3.3 APPLICATION OF MESOPUFF II PREPROCESSORS

The preceding sections described the spatial and temporal scales for applying MESOPUFF II to regulatory problems, and discussed the meteorological data base that is needed to perform such applications. This section contains recommendations for using the meteorological data base with the two MESOPUFF II preprocessors to generate the information used by the model in a simulation. As described in Section 2.2, the READ56 preprocessor is used to screen upper air data and to produce output files for use by the second preprocessor, MESOPAC II. MESOPAC II uses the upper air data and the CD144 hourly surface data along with other information to construct the temporally and spatially varying fields of meteorological data used by MESOPUFF II. The use of each preprocessor is discussed separately below. In these discussions and the ones that follow, reference is made to some of the variable names used in the MESOPUFF II User's Manual, and these are shown in capital letters.

Table 3-2

Land Use Categories Used in MESOPAC II*

Category	Land Use Type
1	Cropland and Pasture
2	Cropland, woodland and grazing land
3	Irrigated crops
4	Grazed forest and woodland
5	Ungrazed forest and woodland
6	Subhumid grassland and semiarid grazing land
7	Open woodland grazed
8	Desert shrubland
9	Swamp
10	Marshland
11	Metropolitan city
12	Lake or ocean

*adapted from reference 1

individual receptor points that can be specified in one of two ways: as part of a gridded sampling network, or as discrete nongridded points. With the procedure that is recommended under this protocol, MESOPUFF II is used to compute one-hour average pollutant concentrations at each receptor for each hour of the simulation. The results are saved on a computer output file, and later used to calculate concentrations for longer averaging periods (e.g., 3 hours, 24 hours and annual). This last procedure is discussed further in Section 3.5.

As noted above, two types of receptor networks can be specified for MESOPUFF II applications, and both types may be used in the same run. The particular network(s) that is chosen for any one application will necessarily have to be determined on a case-by-case basis depending on the purpose of the application. For example, if the application is intended to assess impacts at a remote Class I PSD area alone, receptor locations would normally be restricted to the proximity of the area of concern. If the intent of the application is to identify maximum impacts of a source at distances greater than 50km downwind regardless of where they occur, then the receptor network would have to cover a much broader area. Because it is not possible to identify critical short-term periods without first running the model, it will not be possible to perform screening tests to identify areas with potentially high concentrations. Although exceptions may occur, higher concentrations tend to be found nearer the source in long range transport problems. Thus, a polar coordinate network may be more suited for evaluating source impacts over large areas since the receptors are more closely spaced along rings nearer the source. Conversely, a rectangular gridded network may be more appropriate for assessing impacts in well defined, limited areas. Examples of both are illustrated in the example problem described in the next chapter. Although the use of a large number of receptors may be desirable to obtain good spatial coverage, it should be emphasized that computational requirements increase with the number of receptors used.

MESOPUFF II was originally designed to simulate the transport, dispersion, transformation/formation, and removal of up to five specific individual species: SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-. For the regulatory applications covered by this protocol, however, it is recommended that the pollutant transformation and removal mechanisms currently incorporated in MESOPUFF II not be used. Considerable research is underway to develop techniques for quantifying the effects of these phenomena, but no single set of approaches has yet gained universal acceptance. As a consequence, it is recommended that emissions of relatively nonreactive pollutants such as SO_2 and particulate matter be modeled as if they do not react nor are removed from the atmosphere over the transport distances for which MESOPUFF II is applicable. Sensitivity tests conducted with MESOPUFF II indicate that including chemical transformation and dry removal in simulations of SO_2 lowers the highest and second highest concentration by about 20 to 30 percent over distances of 50 to 300km downwind from an elevated source. Nevertheless, these reductions might be offset by considering a longer period of record in an analysis (i.e., conducting multi-year simulations). Until such time as transformation and removal processes become better understood and approaches for quantifying their effects are agreed upon, the most viable approach for dealing with relatively inert pollutants in a regulatory framework is to assume that plume mass is conserved.

Reference 5 contains recommended procedures for deriving appropriate stack parameters for the representative source. Finally, the x and y coordinates (relative to the meteorological grid) for the nongridded receptors, if any, are input with the last group of variables. Again, these inputs will typically be determined on a case-by-case basis.

<u>Recommended Procedure</u>. Many of the inputs for MESOPUFF II applications must be determined on a case-by-case basis (e.g., receptor network specification, number of species, number of sources, etc.). Specific recommended procedures include: 1) computing one hour averages; 2) setting the puff release rate to four; 3) setting the minimum sampling rate to two and using the variable sampling option with a reference wind speed of 2 m/s; 4) setting the minimum age for puff sampling to 900s; 5) using an initial Gaussian distribution of puffs in the vertical; 6) not including chemical transformation, dry deposition, or wet removal in simulations; 7) not using the three vertical layer option; and 8) using all other default options. Specific inputs corresponding to these selections are listed below, and key assumptions associated with all recommendations are summarized in Table 3-5.

```
IAVG=1
NPUF=4
NSAMAD=2
LVSAMP=TRUE
WSAMP=2.
AGEMIN=900
LGAUSS=TRUE
LCHEM=FALSE
LDRY=FALSE
LWET=FALSE
L3VL=FALSE
IOPTS(1)=0
IOPTS(2)=0
    •
    •
    •
IOPTS(6)=0
```

Table 3-5

Summary of Default Procedures Recommended for Regulatory Applications of MESOPUFF II

---

1) One hour average concentrations are computed.

2) Gaussian vertical concentration distribution is assumed for each puff introduced into the mixed layer.

3) For distances up to 100km, the dispersion parameters are from functions fitted to the curves of Turner.[6] For longer travel distances, time dependent growth functions from Heffter are used.[7]

4) Growth rates for puffs above the mixed layer are those corresponding to E stability.

5) Chemical transformation, dry deposition, and wet removal processes are not included in the simulations.

6) The three vertical layer option is not used.

7) Four puffs are released from a source each hour, variable sampling rates are used depending on wind speed, and no puff is sampled within the first 900 seconds of its release.

---

concentrations are available. These calculations can be performed by using the MESOPUFF II postprocessor (MESOFILE) or software developed by the user.

The concentration estimates output by MESOPUFF II represent the total impacts of all sources in a simulation, and the program is not designed to produce a source contribution file. Thus, some special considerations may be required for evaluating the effects of lowering (or raising) emissions from an established base case (e.g., evaluating a control strategy). When only one source has been included in a simulation, the estimated air quality concentrations are directly proportional to the source emission rate. Thus, the effects of changes in emissions can be evaluated directly without rerunning the model. Further, if two pollutants are being modeled in this situation, some computer time could be saved by modeling only one pollutant and deriving the results for the other by scaling according to the ratio of the emission rates.

Control strategy evaluation is more complicated when multiple sources are included in a simulation. If an estimated concentration exceeds some acceptable limit, a control strategy could always be evaluated by changing source emission rates and rerunning the model for the entire year. This can be relatively expensive, however, especially if a large number of strategies are to be evaluated. Some savings may be realized if only a few, short-term episodes are identified as needing additional evaluation (assuming the emission rate at any source is not increased). In this case, only the critical short-term periods would need to be remodeled, but it would be necessary to begin the simulation at least four days prior to the episode of interest. If a large number of episodes are found in which a concentration estimate exceeds an acceptable value, however, it may be easier to rerun the full year with new emission rates. Of course, the full year would need to be rerun if a predicted annual average concentration exceeded an acceptable limit.

Recommended Procedure. Concentration estimates for averaging periods longer than one hour (e.g., 3 hours and 24 hours) should be computed as nonoverlapping (i.e., block) averages. Annual averages concentrations should be computed using all hourly estimates. If only one source is included in a simulation, predicted concentrations are directly proportional to emission rates, and control strategies can be evaluated directly without rerunning a full annual simulation. If multiple sources are included in a simulation, control strategy evaluations must be carried out using MESOPUFF II to evaluate all critical short-term periods, either by simulating a full year or by modeling episodes only if unacceptably high concentrations are found for short-term periods alone.

Appendix F

Extracted Sections of MESOPUFF II User's Guide

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Extracted Sections of MESOPUFF II User's Guide

PB84-181775

User's Guide to the MESOPUFF II Model and Related Processor Programs

Environmental Research and Technology, Inc.
Concord, MA

Prepared for

Environmental Sciences Research Lab.
Research Triangle Park, NC

Apr 84

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
NTIS

PB84-151775

EPA-600/8-84-013
April 1984

FOC John Irwin
919-541-5682

USER'S GUIDE TO THE MESOPUFF II MODEL AND RELATED PROCESSOR PROGRAMS

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16. ABSTRACT

A complete set of user instructions are provided for the MESOPUFF II regional-scale air quality modeling package. The MESOPUFF II model is a Lagrangian variable-trajectory puff superposition model suitable for modeling the transport, diffusion, and removal of air pollutants from multiple point and area sources at transport distances beyond the range of conventional straight-line Gaussian plume models (i.e., beyond ∿ 10-50 km). It is an extensively modified version of the MESOscale PUFF (MESOPUFF) model with refined and enhanced treatment of advection, vertical dispersion, removal, and transformation processes.

The MESOPUFF II model is one element of an integrated modeling package that also includes components for preprocessing of meteorological data (READ56, MESOPAC II) and postprocessing of concentration data MESOFILE II). Complete user instructions and test case input/output are provided for each of these programs.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 226
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

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PREFACE

This publication contains a technical description and instructions for the use of the MESOPUFF II model and its processor programs. The preprocessor programs need hourly meteorological surface, twice-daily upper air, and hourly precipitation (optional) data in the formats archived by the National Climatic Center in Asheville, North Carolina. The model utilizes the Gaussian puff superposition approach to simulate a continuous pollutant plume. The model is capable of multi-day simulations and has algorithms for plume rise, transport, chemical transformations, dry deposition, and wet removal. Terrain variations are not accounted for in the model.

The puff superposition approach has not been used extensively in air quality models for the prediction of pollutant concentrations. MESOPUFF II is being made available to promote testing and evaluation of the methods and optional features in the model. MESOPUFF II has no regulatory standing and its application for regulatory purposes should be considered in light of EPA's Guideline on Air Quality Models.

The model version (1.0) documented in this publication represents an attempt to utilize recent scientific information to realistically account for the relevant physical processes active on the regional to long-range scales. Modifications may be made in the future based on results by users and findings from ongoing research programs.

Although attempts have been made to check the computer program code, errors may be found occasionally. Adjustments to the code to suit different computer systems may be required. If there is a need to correct, revise, or update this model, changes may be obtained as they are issued by completing and sending the form on the last page of this guide.

It is anticipated that MESOPUFF II will be made available in the future on the User's Network for Applied Modeling of Air Pollution (UNAMAP) system. A tape of this model or the UNAMAP system may be purchased from NTIS for use on the user's computer system. For information on UNAMAP contact: Chief, Environmental Operations Branch, MD-80, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

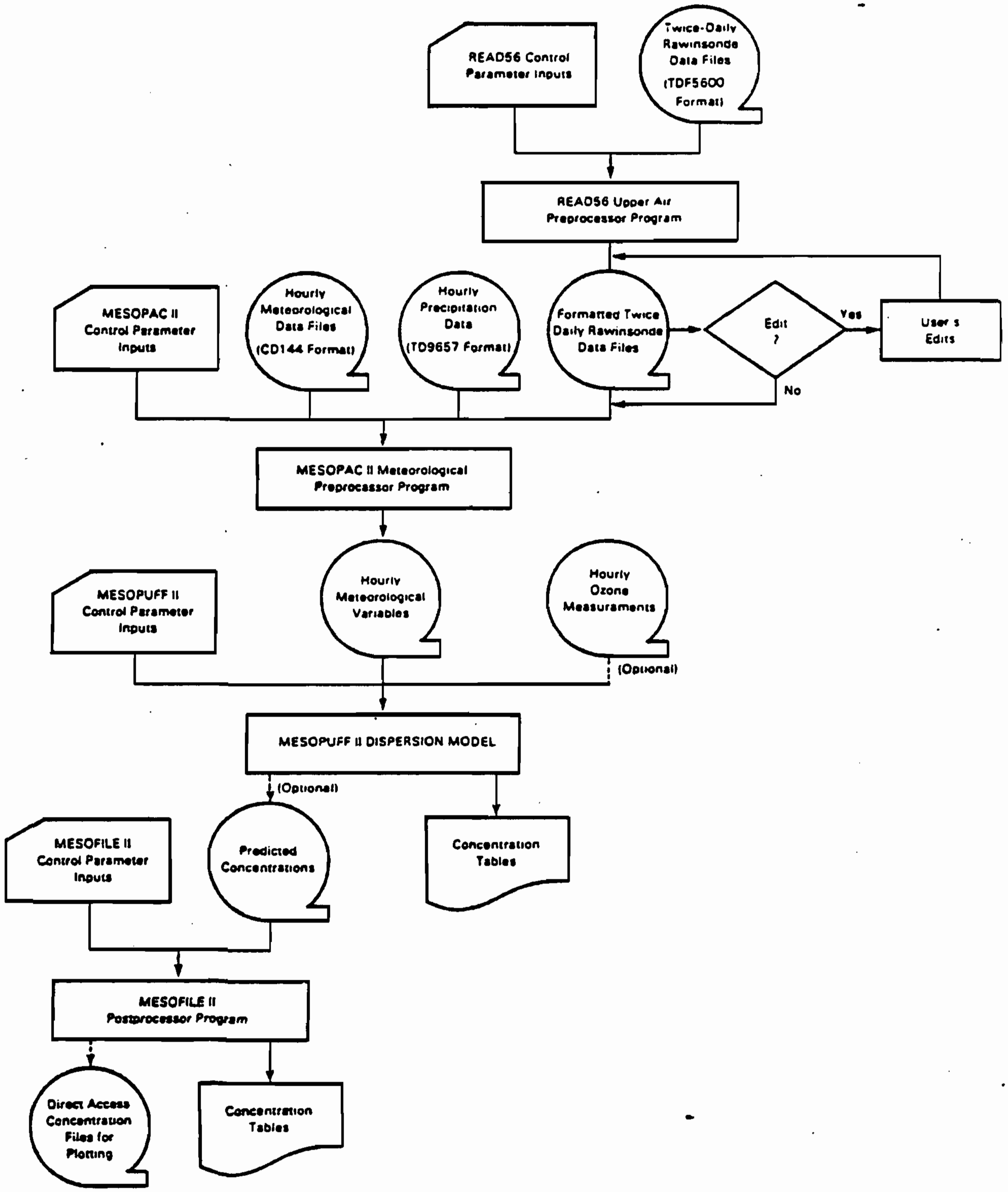

Figure 1 MESOPUFF II Modeling Package

TABLE 1. MAJOR FEATURES OF MESOPUFF II

- Uses hourly surface meteorological data and upper air rawinsonde data
- Wind fields constructed for two layers (within boundary layer, above boundary layer)
- Boundary layer structure parameterized in terms of micrometeorological variables u_*, w_*, z_i, L
- Up to five species (e.g., SO_2, $SO_4^=$, NO_x, HNO_3, NO_3^-)
- Space- and time-varying chemical transformations
- Space- and time-varying dry deposition; resistance model; source or surface depletion
- Space and time-varying wet removal
- Efficient puff sampling function.

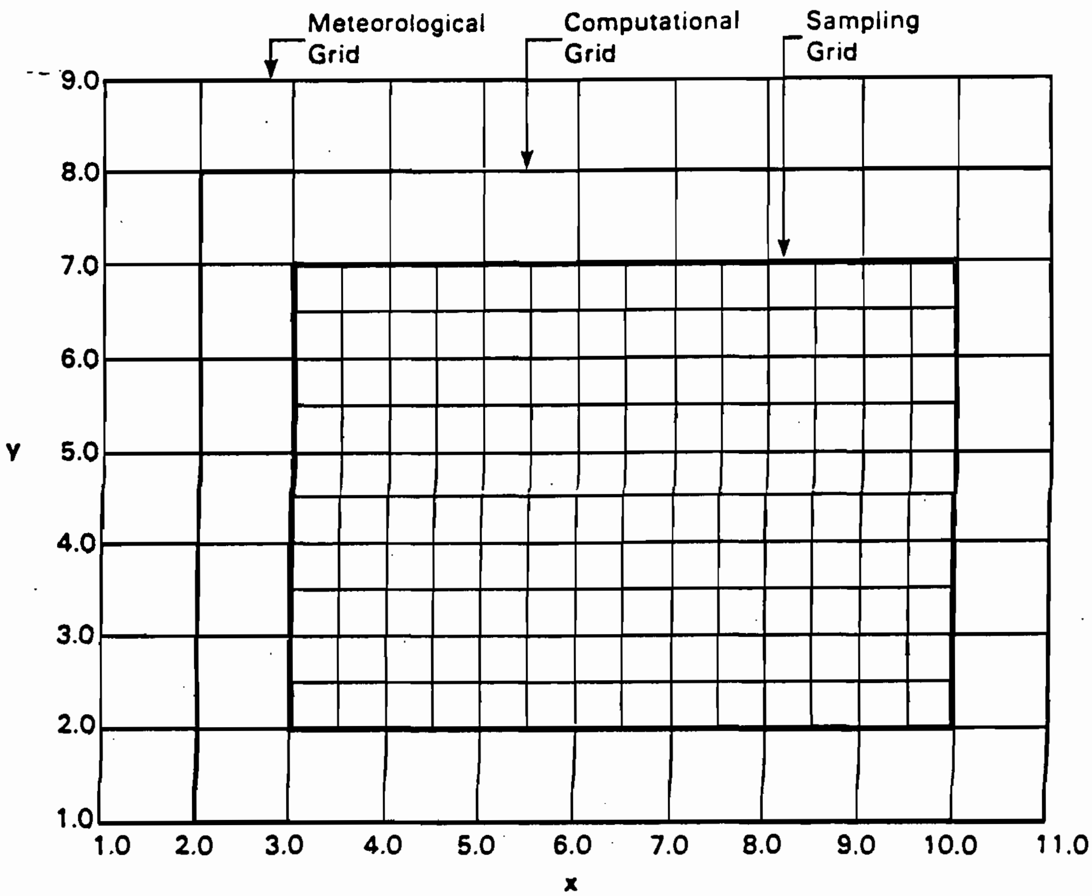

Figure 3 Sample Meteorological, Computational and Sampling Grids

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APPENDIX M

CLASS II SO_2 MODELING SOURCE INVENTORY

County	Facility	UTM East	UTM North	SO2 (g/s)	Height (m)	Temperature (K)	Velocity (m/s)	Diameter (m)
Hardee	Hardee Power Station	404.8	3,057.4	92.53	22.90	389.0	23.90	4.88
Hardee	Hardee Power Station	404.8	3,057.3	92.53	22.90	389.0	23.90	4.88
Hardee	Hardee Power Station	404.8	3,057.5	92.53	22.90	389.0	23.90	4.88
Hillsborough	CF Industries	388.0	3,116.0	88.20	33.50	316.0	19.50	1.50
Hillsborough	CF Industries proposed D	388.0	3,116.0	54.60	60.35	353.0	17.77	2.44
Hillsborough	CF Industries proposed C	388.0	3,116.0	54.60	60.35	353.0	17.77	2.44
Hillsborough	CF Industries baseline C	388.0	3,116.0	−50.40	60.35	353.0	16.40	2.44
Hillsborough	CF Industries baseline D	388.0	3,116.0	−50.40	60.35	353.0	16.40	2.44
Hillsborough	CF Industries	388.0	3,116.0	−105.00	18.80	316.0	18.80	1.52
Hillsborough	Cargill Fertilizer (Gardinier) SAP #7	363.4	3,082.4	46.20	45.72	355.0	9.20	2.29
Hillsborough	Cargill Fertilizer (Gardinier) SAP #8	363.4	3,082.4	52.50	45.72	355.0	8.63	2.44
Hillsborough	Cargill Fertilizer (Gardinier) SAP #9	363.4	3,082.4	54.60	45.72	344.0	12.50	2.74
Hillsborough	Cargill Fertilizer (Gardinier) dryer	363.4	3,082.4	−28.89	20.73	310.0	13.12	1.07
Hillsborough	Cargill Fertilizer (Gardinier) SAP #4, 5, 6	363.4	3,082.4	−196.30	22.60	322.0	19.51	1.52
Hillsborough	Cargill Fertilizer (Gardinier) SAP #7	363.4	3,082.4	−50.71	45.72	355.0	9.20	2.29
Hillsborough	TECO Big Bend − Unit 4	361.9	3,075.0	654.70	149.40	342.2	19.81	7.32
Hillsborough	TECO Big Bend − Units 1 & 2	361.9	3,075.0	−2,436.00	149.40	422.0	28.65	7.32
Hillsborough	TECO Big Bend − Unit 3	361.9	3,075.0	−1,218.00	149.40	418.0	14.33	7.32
Hillsborough	Mobil Big−4 boiler (AMAX)	394.8	3,067.7	0.60	8.20	505.0	7.57	0.41
Hillsborough	Mobil Big−4 dryer (AMAX)	394.9	3,069.8	1.90	30.50	334.0	7.26	1.82
Osceola	FPC/Intercession City prop turbines/7 EA	446.3	3,126.0	124.40	15.24	819.8	56.21	4.21
Osceola	FPC/Intercession City prop turbines/7 FA	446.3	3,126.0	110.40	15.24	880.8	32.07	7.04
Pinellas	Pinellas Co Resource Recovery Facility	335.3	3,084.4	62.24	49.10	522.0	27.72	2.74
Polk	Lakeland City Power CT (Larsen)	409.2	3,102.8	29.11	30.48	783.2	28.22	5.79
Polk	Lakeland McIntosh 3	409.5	3,105.8	500.10	76.20	350.0	19.70	4.88
Polk	WR Grace/Seminole SAP #3	409.8	3,087.0	143.77	60.96	347.0	24.00	1.52
Polk	WR Grace/Seminole SAP #4	409.8	3,087.0	−40.32	60.96	347.0	25.10	1.52
Polk	WR Grace/Seminole SAP #5	409.8	3,087.0	−40.32	60.96	347.0	25.10	1.52

Emission Inventory for PSD Class 2 Analysis for SO2

County	Facility	UTM East	UTM North	SO2 (g/s)	Height (m)	Temperature (K)	Velocity (m/s)	Diameter (m)
Polk	WR Grace/Seminole SAP #6	409.8	3,087.0	−40.32	60.96	347.0	25.10	1.52
Polk	WR Grace/Seminole dryer	409.8	3,087.0	−39.66	15.24	327.0	17.32	2.04
Polk	WR Grace/Seminole SAP #1	409.8	3,087.0	−108.00	45.72	352.0	16.50	1.37
Polk	WR Grace/Seminole SAP #2	409.8	3,087.0	−108.00	45.72	352.0	16.50	1.37
Polk	WR Grace/Seminole SAP #3	409.8	3,087.0	−52.50	45.72	311.0	16.70	1.52
Polk	Mobil Mining & Minerals SR 676 #4 dryer	398.3	3,084.3	2.44	25.90	339.0	15.20	2.29
Polk	Mobil Mining & Minerals SR 676 calciner	398.3	3,084.3	−13.89	28.40	340.0	19.24	1.09
Polk	Mobil Mining & Minerals SR 676 calciner	398.3	3,084.3	−0.87	4.00	522.0	1.80	0.80
Polk	Royster #1	406.7	3,085.2	−152.71	51.00	356.0	9.90	2.13
Polk	Royster #2	406.7	3,085.2	35.70	61.00	360.0	12.20	2.13
Polk	US Agri−Chem Hwy 60 dryer	413.2	3,086.3	−3.41	15.80	332.0	10.01	1.83
Polk	US Agri−Chem Hwy 60 SAP	413.2	3,086.3	−42.00	28.96	305.0	7.50	2.12
Polk	US Agri−Chem Hwy 630 H2SO4 1	416.1	3,068.6	63.00	53.40	355.0	15.91	2.59
Polk	US Agri−Chem Hwy 630 H2SO4 2	416.1	3,068.6	63.00	53.40	355.0	15.91	2.59
Polk	US Agri−Chem Hwy 630 H2SO4 X	416.2	3,068.7	−78.80	29.00	314.0	6.77	3.02
Polk	US Agri−Chem Hwy 630 GTSP	416.0	3,069.0	−18.27	28.35	330.0	17.60	1.52
Polk	CF Industries DAP 1−3	408.5	3,082.5	3.97	36.40	339.0	16.11	2.13
Polk	CF Industries H2SO4 5	408.5	3,082.5	50.40	63.41	361.0	10.88	2.13
Polk	CF Industries H2SO4 6	408.5	3,082.5	50.40	63.41	370.0	7.28	2.13
Polk	CF Industries H2SO4 7	408.5	3,082.5	42.00	67.10	351.0	9.80	2.40
Polk	CF Industries H2SO4 1	408.5	3,082.5	−60.90	30.49	350.0	12.20	1.37
Polk	CF Industries H2SO4 2	408.5	3,082.5	−110.25	30.49	350.0	10.37	1.68
Polk	CF Industries H2SO4 3	408.5	3,082.5	−107.10	30.49	364.0	4.27	2.74
Polk	CF Industries H2SO4 4	408.5	3,082.5	−174.83	30.49	358.0	7.93	2.13
Polk	CF Industries H2SO4 5	408.5	3,082.5	−226.80	63.41	358.0	10.67	2.13
Polk	CF Industries H2SO4 6	408.5	3,082.5	−170.10	63.41	359.0	10.37	2.13
Polk	Farmland Industries 3, 4 H2SO4	409.5	3,079.5	67.16	30.48	355.0	9.27	2.29
Polk	Farmland Industries 5 H2SO4	409.5	3,079.5	41.96	45.72	355.0	9.65	2.44

County	Facility	UTM East	UTM North	SO2 (g/s)	Height (m)	Temperature (K)	Velocity (m/s)	Diameter (m)
Polk	Farmland Industries 1, 2 H2SO4	409.5	3,079.5	−83.98	30.48	311.0	20.18	1.37
Polk	Agrico Pierce dryers 1, 2	404.1	3,079.0	−24.32	24.38	339.0	12.94	1.52
Polk	Agrico Pierce dryers 3, 4	404.1	3,079.0	−23.00	24.38	339.0	18.82	2.43
Polk	Agrico South Pierce H2SO4	407.5	3,071.3	−75.60	45.73	350.0	26.40	1.60
Polk	Agrico South Pierce H2SO4	407.5	3,071.3	113.50	45.73	350.0	39.06	1.60
Polk	Agrico South Pierce DAP plant	407.5	3,071.3	4.41	38.10	328.0	14.60	3.10
Polk	Conserve Inc. rock dryer	398.4	3,084.2	−3.88	24.40	339.0	12.90	1.52
Polk	Conserve Inc.	398.4	3,084.2	42.00	45.70	352.0	10.30	2.30
Polk	Conserve Inc.	398.4	3,084.2	−54.60	30.50	308.0	18.90	1.80
Polk	IMC New Wales DAP	396.6	3,078.9	5.54	36.60	319.1	20.15	1.83
Polk	IMC New Wales multiphos	396.6	3,078.9	4.80	52.40	314.0	15.80	1.40
Polk	IMC New Wales SAP #1, 2, 3 projected	396.6	3,078.9	189.00	61.00	350.0	15.31	2.60
Polk	IMC New Wales SAP #4, 5 projected	396.6	3,078.9	126.00	60.70	350.0	15.31	2.60
Polk	IMC New Wales rock dryer	396.6	3,078.9	−34.27	21.00	347.0	18.60	2.13
Polk	IMC New Wales SAP #1, 2, 3 baseline	396.6	3,078.9	−146.00	61.00	350.0	14.28	2.60
Polk	IMC New Wales AFI Plant	396.6	3,078.9	0.20	52.40	322.0	13.10	2.40
Polk	Mobil−Electrophos boiler	405.6	3,079.4	−6.53	7.32	464.0	3.23	0.91
Polk	Mobil−Electrophos boiler	405.6	3,079.4	−10.05	6.10	464.0	7.71	0.91
Polk	Mobil−Electrophos rock dryer	405.6	3,079.4	−21.81	18.29	350.0	6.79	1.83
Polk	Mobil−Electrophos calciner	405.6	3,079.4	−7.11	25.61	306.0	6.97	2.13
Polk	Mobil−Electrophos coke dryer	405.6	3,079.4	−3.17	18.29	322.0	22.87	0.70
Polk	Mobil−Electrophos furnace	405.6	3,079.4	−47.25	29.27	314.0	8.52	2.13
Polk	Auburndale Cogeneration	420.8	3,103.3	6.35	48.80	411.0	14.30	5.49
Hillsborough	Hillsborough Co Resource Recovery Facility	368.2	3,092.7	21.40	50.00	491.0	18.30	1.80
Pasco	Proposed Pasco Co Cogeneration Facility	385.6	3,139.0	5.04	30.48	384.3	17.13	3.35
Polk	Ridge Cogeneration	416.7	3,100.4	13.80	99.10	350.0	14.54	3.05
Hillsborough	Tampa City McKay Bay Refuse−to−Energy	360.0	3,091.9	21.42	45.70	449.7	21.30	1.34
Hillsborough	CLM ChI	361.8	3,088.3	21.02	30.00	375.0	20.00	0.61

Emission Inventory for PSD Class 2 Analysis for SO2

County	Facility	UTM East	UTM North	SO2 (g/s)	Height (m)	Temper-ature (K)	Velocity (m/s)	Diameter (m)
Pasco	Evans Packing	383.3	3,135.8	0.20	12.30	466.2	9.20	0.40
Hillsborough	Borden dryer	394.6	3,069.6	-6.48	30.48	344.0	14.79	1.82
Polk	Borden dryer	414.5	3,109.0	-5.29	17.07	333.0	8.26	2.34
Polk	Brewster Imperial dryer	404.8	3,069.5	-19.26	27.44	339.0	15.25	2.29
Polk	Dolime dryer	404.8	3,069.5	-5.68	27.43	333.0	20.67	1.52
Polk	Dolime boiler	404.8	3,069.5	-4.52	27.43	494.1	7.25	0.61
Polk	Estech/Swift dryer	411.5	3,074.2	-23.94	18.29	339.0	8.47	2.95
Polk	Estech/Swift dryer	411.5	3,074.2	-22.80	18.75	340.0	5.06	2.95
Polk	Estech/Swift SAP	411.5	3,074.2	-92.87	30.79	358.0	3.90	2.13
Hillsborough	Gen. Port Cement kiln 4	358.0	3,090.6	-62.99	35.97	505.2	17.61	2.74
Hillsborough	Gen. Port. Cement kiln 5	358.0	3,090.6	-69.30	45.42	494.1	5.80	3.81
Highlands	TECO Sebring Airport	464.3	3,035.4	55.62	45.72	441.3	24.10	1.83
Highlands	TECO Sebring Airport	464.3	3,035.4	55.62	45.72	449.7	24.35	1.83
Polk	FPC Polk	414.4	3,073.9	12.36	34.40	400.0	40.50	4.10
Polk	FPC Polk	414.4	3,073.9	12.36	34.40	400.0	40.50	4.10
Polk	FPC Polk	414.4	3,073.9	12.36	34.40	400.0	40.50	4.10
Polk	FPC Polk	414.4	3,073.9	12.36	34.40	400.0	40.50	4.10
Hillsborough	Couch Construction	362.1	3,096.7	2.14	12.50	449.7	20.12	1.25
Polk	TECO Polk	402.5	3,067.4	49.68	45.72	400.0	16.76	5.79
Polk	TECO Polk	402.5	3,067.4	17.64	45.72	389.0	16.15	4.42
Polk	TECO Polk	402.5	3,067.4	38.82	22.86	785.0	27.43	5.49
Polk	TECO Polk	402.5	3,067.4	8.20	60.70	1033.0	10.70	1.40