July 29, 1999

Mr. Cleve Holladay
Bureau of Air Quality Management
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

RE: AIR MODELING PROTOCOL TO CONDUCT A REFINED REGIONAL HAZE ANALYSES FOR THE PROPOSED JEA BRANDY BRANCH FACILITY - DRAFT

Dear Cleve:

On behalf of the Jacksonville Electric Authority (JEA) and their engineers Black & Veatch (B&V), Golder Associates Inc. (Golder) is providing this air modeling protocol to the Florida Department of Environmental Protection (FDEP) for performing a refined regional haze analysis. The purpose of the protocol is to help ensure that the air modeling analyses will be performed in a manner that will conform to FDEP requirements, as well as those of the U.S. Fish and Wildlife Service (USFWS).

The proposed analysis is to help determine if the proposed facility's maximum emissions alone would have an adverse affect on existing regional haze levels at the Okefenokee National Wildlife Refuge (ONWR), a Prevention of Significant Deterioration (PSD) Class I area located approximately from 34 to 96 km north-northwest of the proposed facility site. This analysis being performed as a refinement of a previous Level II regional haze screening analysis provided by JEA in DRAFT to the FDEP dated June 23, 1999. However, the conservative modeling protocol employed by the Level II screening analysis was not able to demonstrate that the proposed facility will insignificantly impact regional haze. Based on previous telephone communications between B&V, JEA, and Golder with the FDEP, this refined analysis is to assess the regional haze impacts at the ONWR exclusively.

The refined modeling analysis will follow those procedures recommended in the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase II report dated December 1998 in coordination with the FDEP. This protocol includes a discussion of the databases to be used in the analysis, the preparation of the modeling databases for introduction into the modeling system, the air modeling methodology, and the presentation of the air modeling results. The proposed model parameter settings are discussed below.

Model Selection

The California Puff (CALPUFF, version 5.0) air modeling system will be used to model JEA's proposed facility and assess visibility at the ONWR. CALPUFF is a non-steady state Lagrangian Gaussian puff long-range transport model that includes algorithms for building downwash effects as well as chemical transformations (important for visibility controlling pollutants), and wet/dry deposition. The CALMET model, a preprocessor to CALPUFF, is a diagnostic meteorological model that produces a three-dimensional field of wind and temperature and a two-dimensional field of other meteorological parameters. Simply, CALMET was designed to process raw meteorological, terrain, and land-use databases to be used in the air modeling analysis. The CALPUFF modeling system uses a number of FORTRAN preprocessor programs that extract data from large databases and converts the data into formats suitable for input to CALMET.. The processed data produced from CALMET will be input to CALPUFF to assess the pollutant specific impact. Both CALMET and CALPUFF will be used in a manner that is recommended by the IWAQM Phase 2 Report. The proposed analysis will also be based on experience obtained with other recently completed CALPUFF refined modeling analyses in Oregon (Golder, 7/99).

Emission Rates

The stack parameter and emission rates from the proposed facility are presented in JEA's Prevention of Significant Deterioration Air Permit Application for Brandy Branch Facility, submitted to FDEP on May 17 (hereinafter referred to as the PSD Application), and in the aforementioned regional haze Level II screening analyses. The proposed facility's emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulates (PM_{10}) will be included in the refined modeling analysis. The modeling analysis will conservatively assume 100% conversion of NOx emissions to NO_2.

Building Wake Effects

The air modeling analysis will address the potential for building-induced downwash to occur at the proposed facility. Dimensions for all significant building structures, as determined by the Building Profile Input Program (BPIP, version 95086), will be included in CALPUFF model. These building dimensions are the same as those provided in the PSD Application.

Modeling Methodology

The analysis for regional haze will be performed using the refined procedure that is outlined in the IWAQM Phase 2 report. The maximum predicted 24-hour concentrations from the proposed facility will be compared to a five percent change in light extinction over the background level for the ONWR. Based on prior discussions with the FWS, the background extinction coefficient for the ONWR is 60.18 Mm^{-1} which is based on a conservative visual range of 65 km.

The source extinction coefficients will be computed using two different methods for calculating the relative humidity factor. For both methods, the CALPUFF model will be used to predict 24-hour concentrations of nitrates (NO_3), sulfates (SO_4) and PM_{10} for each day of the year. Based on the procedures provided in the IWAQM Phase II summary report, concentrations of $NH_4\ NO_3$ and $(NH_4)_2SO_4$ will be determined by multiplying the maximum predicted NO_3 and SO_4 concentrations by factors of 1.29 and 1.375, respectively (i.e., based on the ratio of the molecular weights).

Method 1 --Daily source extinction coefficients will be determined by multiplying the daily calculated concentrations of $NH_4\ NO_3$ and $(NH_4)_2SO_4$ by calculated daily relative humidity factors. The relative humidity is based on conversations with Bud Rolfson and Ellan Porter of the USFWS and represents the average relative humidity factor corresponding to each hour from the 24 hour period which the maximum pollutant impact occurred. This relative humidity factor does not correspond to the average daily relative humidity. The daily PM_{10} concentrations, because it does not chemically transform into another pollutant species and it is a non-hygroscopic pollutant, will then be added to the daily sums for the other pollutants. The maximum daily source extinction coefficient will be used directly to determine whether the proposed facility's emissions will exceed a 5 percent change in light extinction of the background levels.

Method 2 -- The maximum predicted 24-hour NO_3, SO_4, and PM_{10} concentrations will be determined directly from CALPUFF. Computed values of $NH_4\ NO_3$ and $(NH_4)_2SO_4$ will be multiplied by an annual relative humidity factor, and added to the PM_{10} concentration to calculate the total source extinction coefficient. This annual relative humidity factor corresponds to a value listed in the FLAG document issued by the John Notar at the U.S. National Park Service (USNPS) that contains values for class I areas. Specifically, the annual relative humidity factor for ONWR is 3.92.

Receptor Locations

The CALPUFF refined analysis will use an array of discrete Cartesian receptors at appropriate distances to ensure sufficient density and aerial extent to adequately characterize the pattern of pollutant impacts in the ONWR area. Specifically, the array will consist of receptor spacing of 2 km beginning at 50-km distance from the proposed JEA facility location to the farthest extent of the Class I area. Because the terrain varies very little over the entire the modeling domain, a **flat terrain assumption will be employed in the CALPUFF modeling analysis.**

Modeling Domain

The modeling domain to be used for the analysis will be in the shape of a rectangle extending approximately 360 km in the east-west (x) direction and 250 km in the north-south (y) direction. The southwest corner of the rectangle will be the origin of the modeling domain and is located at 29.25 N degrees latitude and 84 W degrees longitude.

For the processing of meteorological and geophysical data, 75 grid cells will be used in the x-direction and 50 grid cells will be used in the y-direction. A 5-km grid spacing will be used. The air modeling analysis will be performed with the UTM coordinate system.

Mesoscale Model – Generation 4 (MM4) Data

Pennsylvania State University in conjunction with the NCAR Assessment Laboratory developed the MM4 data, a prognostic wind field or "guess" field, for the United States (U.S.). The hourly meteorological variables used to create this data set (wind, temperature, dew point depression, and geopotential height for eight standard levels and up to 15 significant levels) are extensive and only allow for one data base set for the year 1990. The analysis will use the MM4 data to initialize the CALMET wind field. The MM4 data have a horizontal spacing of 80 km and are used to simulate atmospheric variables within the modeling domain.

To apply the MM4 dataset to a regional modeling domain, such as the area that will incorporate JEA's proposed facility and the ONWR, a sub-set domain will be developed based on the MM4 data local coordinate system. In this coordinate system, the subset domain will consist of a 6 x 6- cell rectangle, spaced at 80 km, extending from MM4 coordinates (49,13) to (54,18). These data will be processed to create a MM4.Dat file, which will be input to the CALMET model.

Composite Receptor Array and CALMET Domain

Figure 1 illustrates the relationship between CALPUFF modeling domain, the receptor array, and the MM4 prognostic wind field domain.

Additional Data

The MM4 data set used in the CALMET, although advanced, lacks the fine detail of specific temporal and spatial meteorological variables and geophysical data. These variables will be processed into the appropriate format and introduced into the CALMET model through the additional data files obtained from the following sources.

Surface Data Stations

The surface data processing will include seven primary National Weather Service (NWS) stations that surround the air modeling domain as illustrated in Figure 2. These stations include Jacksonville, Gainesville, Tallahassee, Daytona Beach, and Tampa in Florida and Savannah, Macon, and Columbus in Georgia. The parameters to be included for these stations are wind speed, wind direction, cloud ceiling height, opaque cloud cover, dry bulb temperature, relative humidity, station pressure and precipitation code that is based on current weather conditions. The weather station data for all stations but Gainesville will be downloaded for the year 1990 from the National Climatic Data Center's (NCDC) Solar and Meteorological Surface Observational Network (SAMSON) CD-ROM set. The surface data from Gainesville will be processed from NCDC CD-144 format. The data will be processed with the CALMET preprocessor utility program, SMERGE, to create one surface file. SURF.DAT

Upper Air Data Processing

Upper air data will be processed from four to six weather stations. The four stations that will be included are Tampa Bay/Ruskin, in Florida, Waycross and Athens in Georgia and Charleston in South Carolina. Two other stations at Cape Canaveral and Apalachicola will be examined for completeness and included in the analysis if the data are determined to be suitable for CALMET processing. The upper air data will be obtained from the NCDC Radiosonde Data CD and processed into the NCDC Tape Deck (TD) 6201 format by the CALMET preprocessor utility program, READ62, to create an upper air file for each station.

Precipitation Data Processing

Precipitation data will be processed from a network of hourly precipitation data files collected from primary and secondary NWS precipitation recording stations located in southern Georgia and northern Florida. The stations will be selected so as to provide detailed coverage in all areas around the modeling domain. The data will be obtained from NCDC in a Tape Deck (TD) 3240 format. The preprocessor utility programs PXTRACT and PMERGE will be used to extract and merge the hourly precipitation data into CALMET input format.

Geophysical Data Processing

Terrain elevations for each grid cell of the modeling domain will be obtained from Digital Elevation Model (DEM) files obtained from US Geographical Survey (USGS). The DEM data for the modeling domain grid will be extracted using the utility extraction program LCELEV. Land-use data will also be obtained from the USGS. Land-use parameters for the modeling domain will be obtained by using the CALPMET preprocessor utility program CAL-LAND. Other parameters to be processed include surface roughness, surface albedo, Bowen ratio, soil heat flux, and leaf index field. All of the processed land-use parameters will be combined with the terrain information and converted into CALMET input format.

CALPUFF Settings

The following CALPUFF settings/values as defined in IWAQM Phase II are to be used for the refined modeling analysis:

Parameter	Setting
Six Pollutant Species	SO_2, SO_4, NO_x, HNO_3, NO_3, and PM_{10}
Chemical Transformation	MESOPUFF II scheme with CALPUFF default
Deposition	Use dry and wet deposition, plume depletion
Meteorological/Land Use Input	CALMET
Plume Rise	Transitional, Stack-tip downwash, Partial
Dispersion	Puff plume element, PG /MP coefficients,
Terrain Effects	Partial plume path adjustment
Output	Create binary file: output species SO_4, PM_{10},
Model Processing	Highest concentrations predicted for year
Background Concentrations	Ozone: 60 ppb; Ammonia: 3 ppb

The refined modeling analysis emission parameters for the proposed JEA facility are the same as was used for Level II screening analysis. A discussion of this inventory is presented in the PSD application.

Should you have any questions or comments on the protocol, please contact me. Golder greatly appreciates the cooperation of the FDEP staff on this important project.

Sincerely yours,

Steven R. Marks, CCM
Senior Scientist

cc: B. Giannazza, JEA
M. Bareta, B&V
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Regional Haze Analysis for the Okefenokee Wilderness Area

A regional haze analysis, using the CALPUFF Lite Approach, was performed in accordance with guidance published in the IWAQM Phase II document, as well as technical guidance and an example provided by the NPS, and conversations with Ellen Porter and Bud Rolofson at the FWS to evaluate the potential for visibility impairment (significant increase in uniform haze) at the Okefenokee Wilderness area. Visibility impairment occurs as a result of the scattering and absorption of light due to particles and gasses in the atmosphere. On a local-scale, visual impairment is generally defined as a plume or layered haze from a single source or small group of sources. This phenomena, known as regional haze, impairs visibility in all directions over a large area by obscuring the clarity, color, texture, and form of what is seen. The methodology, input, and results are described in the following subsections.

Analysis Methodology and Input The reduction of image forming light per unit distance in the atmosphere due to the sum of scattering (light redirected away from the sight path) and adsorption (light captured by aerosols and turned into heat energy) is represented by a term known as the extinction coefficient (b_{ext}). Visual range (vr) is a measure of how far away a large black object can be seen in the atmosphere under several severe assumptions including: an absolutely dark target, uniform lighting conditions (cloud free skies), uniform extinction in all directions, a limiting contrast discrimination level (usually set at 2% difference between target and sky), a target high enough in elevation to account for earth curvature, and several other factors. Visual range is, at best, a limited concept that allows relatively simple comparisons between visual air quality levels and should not be thought of as the absolute distance that can be seen through the atmosphere. With the aforementioned assumptions, extinction can be related to visual range with the following equation:

$$b_{ext} = \frac{3,912}{vr}$$

Where: b_{ext} = extinction coefficient, 1/Mm
vr = visual range, km

A uniform incremental change in b_{ext} or visual range does not necessarily result in uniform changes in perceived visual air quality. In fact, perceived changes in visibility are best related to a change in b_{ext}, or; percent change in extinction. Based on NPS guidance, the percent change in extinction is calculated as follows:

$$\text{Percent Visual Change} = \frac{b_{exts}}{b_{extb}}(100\%)$$

Where: b_{exts} = source extinction coefficient
b_{extb} = background extinction coefficient

The source extinction coefficient is calculated as a function of the source's NO_3, SO_4, and fine PM model predicted concentration levels at the Class I area, as well as the ambient relative humidity. Although relative humidity does not by itself cause visibility to be degraded, some particles in the atmosphere accumulate water and grow to just the right size to be very efficient at scattering light. Based on guidance from the IWAQM documents, NPS, and FWS the source extinction coefficient may be calculated as follows:

$$b_{exts} = (3)(RH_f)[(NH_4)_2SO_4] + (3)(RH_f)[NH_4NO_3] + (1)(PM_{fine})$$

Where: RH_f = relative humidity correction factor to adjust for the effects of ambient humidity on light extinction calculations.

NH_4NO_3 = concentration of ammonium nitrate in units of □g/m^3, calculated as (NO_3 24-h concentration, □g/m^3)(1.29), assuming all NO_x converts to ammonium nitrate.

$(NH_4)_2SO_4$= concentration of ammonium sulfate in units of □g/m^3, calculated as (SO_4 24-h concentration, □g/m^3)(1.375), assuming all SO_2 converts to ammonium sulfate.

PM_{fine}= concentration of primary fine particulate in units of □g/m^3, calculated as (PM/PM_{10} 24-h concentration, □g/m^3)(1.0), assuming all PM/PM_{10} is primary fine particulate.

The background extinction coefficient is calculated as a function of the estimated visual range as follows:

$$b_{extb} = \frac{3{,}912}{vr}$$

Where: b_{extb} = background extinction coefficient, 1/Mm
vr = background visual range, km

Regional Haze Calculations and Results. Based on the aforementioned methodology, the percent change in extinction for normal SCCT operation (operating parameters are contained in Table 4-1 of the Prevention of Significant Deterioration Air Permit Application for Brandy Branch Facility document) and 5 years of meteorological data was assessed in CALPUFF Lite analysis. The results of the analysis are presented in Table 1. The CALPUFF air dispersion model was used to determine the maximum predicted 24-hour impacts of NO_3, SO_4, and PM/PM_{10}. Actual relative humidity data corresponding to the date of the maximum predicted NO_3 and SO_4 impacts for each scenario were used in the regional haze calculations. The results of the analysis are presented in Table 2.

Table 1
CALPUFF Lite Air Dispersion Modeling Performed for the Okefenokee Wilderness Area[a]

Scenario	PM_{10} Impact ($\mu g/m^3$) [b]	NO_3 Impact ($\mu g/m^3$) [b]	Date of NO_3 Impact	Relative Humidity Factor	SO_4 Impact ($\mu g/m^3$) [b]	Date of SO_4 Impact	Relative Humidity Factor[c]	Background Visual Range (Mm^{-1}) [d]	Change in Visibility (%)
Natural Gas[e]	0.0438	0.1106	12/23/87	7.8	0.0009	12/23/87	7.8	60.18	5.6
Fuel Oil[d]	0.0819	0.4536	12/23/87	7.8	0.0804	12/23/87	7.8	60.18	27.2

[a]A regional haze analysis, using the CALPUFF Lite Approach, was performed in accordance with guidance published in the IWAQM Phase II document, as well as technical guidance and an example provided by the NPS, and conversations with Ellen Porter and Bud Rolofson at the FWS to evaluate the potential for visibility impairment (significant increase in uniform haze) at the Okefenokee Wilderness area.
[b]The results represent the #1 Ranked summarized impact as given in CALPOST.
[c]The relative humidity factor represents the average relative humidity factor corresponding to each hour from the 24 hour period which the maximum pollutant impact occurred. The relative humidity factor does not correspond to the average daily relative humidity.
[d]The background visual range was given by the FWS and is based on 65 km.
[e]Natural gas operation represents normal facility operation as described in the Prevention of Significant Deterioration Air Permit Application for Brandy Branch Facility document. Specifically, 4,000 hours of natural gas firing per simple cycle combustion turbine.
[d]Fuel oil operation of 800 hours per simple cycle combustion turbine as described in the Prevention of Significant Deterioration Air Permit Application for Brandy Branch Facility document is a backup operating scenario when natural gas fuel is unavailable.

APPENDIX E

IWAQM PHASE II CALPUFF DEFAULT OPTIONS