Visibility Impairment

Visibility impairment can be defined in one of two ways, plume impairment and uniform haze impairment. Plume impairment occurs when a coherent pollutant stream, a plume, becomes visible against a viewing background such as a hillside or the sky. Plumes become visible when the color difference between the plume and the background becomes apparent. As the plume travels downwind and begins to disperse within the mixed layer, its shape becomes less defined and appears as a general haze that starts to obscure distant objects and alters the appearance of nearby objects. This type of impairment is referred to as uniform haze impairment.

Plume impairment generally occurs near the point of release and is calculated based upon differences in contrast and color difference. Visibility impairment for sources within 50-kilometers of a Class I area is calculated based upon plume impairment where near steady state conditions may occur allowing the plume to remain cohesive.

As noted previously, uniform haze impairment occurs as the plume travels downwind and begins to disperse resulting in the alteration of the background viewing area. Visibility impairment for sources greater than 50-kiloemters from a Class I area is calculated based upon the change in atmospheric light extinction between natural conditions and hazy conditions.

Near Field Visibility Assessments

If a facility is located within 50-kilometers of a Class I area, a near field visibility assessment should be conducted using the screening model, VISCREEN. As recommended in the VISCREEN User's Guide, a Level 1 screening analysis should initially be performed using the worst case meteorological conditions and a plume/observer relationship that places the plume adjacent to the observer. The Level-1 screening analysis does not require the user to specify raw meteorological data inputs because the model assumes that the worst case stability, wind speed and wind direction are occurring.

In order for VISCREEN to calculate the difference in contrast and the color difference parameter (delta-E) the user must provide the maximum short-term emissions information for both particulate matter and oxides of nitrogen. It is important to note that sulfur dioxide emissions are not a required input into VISCREEN because sulfate formation is not instantaneous and is unlikely to occur over the short distances that are considered for the near-field Class I visibility assessment.

In addition to the input of the emission rates, the user is also required to input the distance between the source and the boundary of the sensitive area being evaluated and the background visual range. Figure 9 contained within the document entitled "Workbook for Plume Visual Impact Screening and Analysis (Revised)" contains background visual range values for the entirety of the United States and should be used to define this value for the Level 1 analysis.

Upon execution, the VISCREEN model compares the contrast and color difference parameters to pre-defined adverse impact thresholds for Class I areas. If the thresholds are exceeded, the user should move forward with a Level 2 screening analysis.

Unlike the Level 1 analysis, the Level 2 screening analysis requires an evaluation of both the frequency and distribution of wind speed and direction in order to determine if the plume will remain cohesive as it travels towards the observer located within the area of interest. If the plume is dispersed due to convective activity, it is unlikely that any discoloration of the atmosphere will be visible.

Prior to performing the Level 2 analysis, the applicant should construct a meteorological database that includes the joint frequency of occurrence of wind speed, wind direction, and stability class. Once the meteorological data is tabulated, maps of the source/observer relationship should be reviewed so that the wind sector that transports emissions closest to the observer can be determined. For each critical wind direction, the worst case dispersion characteristics should be ranked in order of severity along with the frequency of occurrence. A table should be created that includes a summary of the worst case meteorological conditions, transport time associated with each condition and the frequency of occurrence for each sensitive area for each meteorological period included in the air quality analysis. The stability class and wind speeds should be based upon the one percentile meteorology identified in the frequency distribution tables. The one percentile meteorology occurs when the most severe meteorological conditions are coupled with other factors that contribute to maximum plume visual impacts.

If visible impacts continue to be likely at the sensitive areas identified in the air quality analysis, the applicant should investigate the ambient conditions that resulted in the adverse impacts, i.e. time of day, wind speed, stability class, etc. For example, if the worst case meteorological conditions occurred during the late evening and early morning hours when wind speeds decrease and atmospheric stability increases the plume may not be visible. Additionally, the use of typical nighttime conditions will yield conservative results because low wind speeds and stable conditions are likely to occur immediately after sunrise and the likelihood that they would persist for multiple hours after sunrise is small.

The criteria used to determine plume visual impacts within the VISCREEN modeling system were developed to protect Class I areas from harm. If adverse impacts are predicted to occur, a more refined analysis, which incorporates particle size distributions, plume overlap, and different geometries, could lead to improved Class I visibility results. The consideration of a more sophisticated model could also lead to improved visibility predictions if the facility fails to meet the Level 2 adverse impact thresholds.

Far Field, Multi-Distant Visibility Assessments

If a facility is located more than 50-kilometers from a Class I area, a far field visibility assessment should be conducted through the execution of the CALPUFF modeling system, refer to the following documents for recommendations and default modeling options: Meteorological Data & CALMET and Emissions Data, Receptor Grids & Other CALPUFF Inputs.

Visibility Impairment

The CALPUFF modeling system will produce a concentration file for use in the post processing tool, CALPOST. CALPOST will determine if the change in light extinction is below the Federal Land Managers (FLMs) 5% screening threshold. In order to calculate the change in light extinction, the applicant is required to select the method that will be used to calculate this difference. The FLAG2010 document entitled, "Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report-Revised (2010)," suggests that the CALPOST parameter MVISBK be set to option #8, sub-mode #5.

MVISBK option #8, sub-mode #5 utilizes the IMPROVE equation for calculating the change in light extinction. In addition to selecting the change in extinction calculation method, the applicant must provide background levels for hygroscopic and non-hygroscopic aerosol levels based upon the data contained within Table 6 in the FLAG2010 guidance document referenced above. The last input that must be provided is the relative humidity adjustment factors which are also provided for each Class I area in Table's 7-9 within the FLAG 2010 document.

In order to determine if a cumulative visibility assessment is necessary, the applicant must compare the 98th percentile of the modeled visibility values to the 5% change in extinction threshold. The 98th percentile allows the applicant to exclude the top seven extinction values from each year modeled.

If the predicted values exceed the 5% screening threshold, the FLM should be contacted for additional guidance. Contact information for the FLMs can be found in the following document: Class I Areas and the Federal Land Managers.