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The following three questions have been posed by EPA Region 4. Response to these questions may be sufficient demonstration that ISC-PRIME is an acceptable model for the Dan River Steam Station air quality analysis. The responses provided below are based largely upon the independent model evaluation of ISC-PRIME and ISCST, which is available on EPA's SCRAM webpage, http://www.epa.gov/ttn/scram/t29.htm - iscprime. In fact, extensive portions of the responses are taken directly from, or paraphrase the independent evaluation.

1. **Why does ISC-PRIME offer a better theoretical simulation of the problem?**

   The Industrial Source Complex (ISC3) model was largely developed with data that represented neutral stability, moderate to high wind speeds, winds perpendicular to the building face, and nonbuoyant or low buoyancy plumes. The ISC3 model does not include several important features: the stack location with respect to the building, the influence of streamline deflection on plume trajectory, the effect of wind angle on wake structure and the effects of plume buoyancy and vertical wind speed shear on plume rise near buildings. Proper treatment of all of these factors is essential characteristics of the enhanced plume rise and building downwash model that is part of ISC-PRIME.

   ISC-PRIME provides a better theoretical simulation of downwash in general, compared to ISC3. There are three complementary reasons for this. First, advances in field data and wind tunnel data collection techniques allow for much higher quality of data to be available for researchers to analyze as the basis for designing a model. Second, ISC-PRIME is based on a much more extensive database of wind tunnel simulations and field data than was used in the development of the downwash algorithm in ISC3. Third, advances in computer processing speed have made it more practical to include more of the detailed physics of the downwash phenomenon; ISC-PRIME takes about 7 times longer to run than does ISC3.

   ISC-PRIME explicitly treats the trajectory of the plume near the building and uses the position of the plume relative to the building to calculate interactions with the building wake. The trajectory of the rising plume downwind of a building is the result of two processes: (1) descent of the air containing the plume material, and (2) rise of the plume relative to the streamlines due to buoyancy or momentum effects. For a given source-building configuration, the dominant effect depends on the wind direction relative to the building face (affecting the amount of streamline descent) and the wind speed (controlling the rate of rise of the plume.) ISC-PRIME calculates the local slope of the mean streamlines as a function of building shape and wind angle, and coupled with a numerical plume rise model, determines the change in plume centerline location with downwind distance.

   This approach in ISC-PRIME addresses the current deficiencies in the downwash algorithm of the ISC3 model. Since the plume position relative to the building is used to calculate the plume trajectory, the stack location in ISC-PRIME is an

important input parameter. Plumes released upwind of a building will initially have an ascending component, and then, as the plume travels downwind of the building, a descending component. The magnitude of the streamline deflection decreases both laterally and vertically from the building, so that a plume released to the side of a building will be less affected than a plume released on or directly downwind of a building.

PRIME predicts concentrations in both the near and far wakes. Currently, the ISC3 model is only valid for the far wake (defined in ISC3 as beyond the lesser of three building heights or building widths). A separate model, SCREEN3, is recommended by EPA for near-wake concentrations. ISC-PRIME is capable of modeling the range of concentrations from the building face itself, through the near wake (e.g., the wake cavity), through the far wake, and beyond.

2. **Based on the available performance evaluation data for ISC-PRIME, why would ISC-PRIME be expected to perform better than ISC3 for this application. To do this latter evaluation, the source/state should identify the evaluation data base(s) that is (are) similar to the situation for the proposed source. To assess similarity, the building/source geometry and the stack effluent characteristics should be compared for the evaluation database and the proposed source. This could include a comparison of the stack height to building height ratios, and a comparison of the momentum and buoyancy fluxes.**

The independent evaluation of ISC-PRIME provided the following overall conclusions:

- "ISC-PRIME is generally unbiased or overpredicts, so its use is protective of air quality."
- ISC3 "is especially conservative in stable conditions, and ISC-PRIME performs much better under these conditions. This disparity between model performance appears to be most notable for buoyant point sources...."
- "Under neutral conditions, the performance of the two models is more comparable, but ISC-PRIME is somewhat better...."
- ISC-PRIME has a statistically **better** performance result for **each** data base in the independent evaluation." [bold added for emphasis]

The independent evaluation included a variety of stack configurations. Except for the non-buoyant EOCR tracer, the stack data cover a range typical for most power plants. In addition, the range of stack height to building height ratios covered the general range of situations often modeled for downwash. The stack data used in the evaluation study are provided in the table below. Supplementing that data are SCREEN3 calculations of momentum and buoyancy fluxes. The Dan River Steam Station is added at the bottom of the table for comparison purposes.

The range of Dan River data reflects the range of existing stack heights and exhaust data for 100% load and 50% load. The table shows that the Dan River Steam Station falls

within the range of stack-to-building height ratios of the evaluation study. In addition, the Dan River Steam Station falls within the range of range of momentum and buoyancy fluxes included in the evaluation study. Therefore, it is reasonable to conclude that ISC-PRIME will provide superior performance to ISC3 in modeling air quality impacts due to Dan River emissions.

Plant Name	Stk ht (m)	Bldg ht (m)	Stk ht to bldg ht ratio	Exit Temp (K)	Exit Vel. (m/s)	Stk Dia. (m)	Momentum flux m^4/s^2	Bouyancy flux m^4/s^3
Lee	65	42.55	1.53	440	17	2.5	301	87
Bowline	87	65.2	1.33	370 - 400	10 - 30	5.7	5357	638
AGI tracer	10, 25	10	1 to 2.5	620 - 640	8 - 9	0.6	3.4	4.2
EOCR tracer	1, 25, 30	25	0.04, 1.00, 1.2	Ambient				0
Dan River	54.9, 57.3	49.15	1.12, 1.17	448, 439	23.13, 24.1	3.2, 2.74	171 - 896	60 - 201

3. **Discuss the model evaluation of the ISC-PRIME model.**

EPRI contracted with ENSR to prepare existing data bases for use in model development as well as an independent ("hands-off") model evaluation study. The four data sets reserved for the independent model evaluation are briefly summarized in detail in the report, **"Results of the Independent Evaluation of ISCST3 and ISC-PRIME,"** available from EPA (http://www.epa.gov/ttn/scram/t29.htm#iscprime).

For the Bowline Point 1-year database, each model was run for the full year with hourly emissions, and concentration predictions were obtained at four close-in monitors. Products resulting from the evaluation include tabulations of the top several observed and predicted concentrations at each monitor, quantile-quantile plots of ranked 1-hour predicted versus observed concentrations at each monitor (for all cases as well as certain meteorological classes), and other assorted concentration scatterplots and residual plots of the ratio of the predicted to the observed concentration (C_p/C_o) versus variables such as windspeed.

For the tracer databases (EOCR and AGA), the observed data for each hour and arc of monitors were carefully analyzed to determine the locations of the peak concentrations on the monitoring arcs. The models were then run with the plume directed toward the peak observed concentration. There were 214 arc-hours available from the EOCR data set, and 78 arc-hours from the AGA data set. A Gaussian fit to the arcwise observed concentrations in the vicinity of the peak location was computed and was used as the appropriate observed value for comparing predicted values against. For these two data bases, concentration scatterplots as well as several residual plots of (C_p/C_o) against variables such as distance and stability class were prepared.

The wind tunnel observed concentrations (Lee Power Plant) were available in the form of one "centerline" concentration at various distances. The models were run by advecting the plume directly toward the line of monitors. A total of 1,062 arc-hours were available for the Lee data set. Concentration scatter plots and residual plots similar to those

produced for the tracer databases were produced.

Other evaluation procedures involved computing test statistics from the observed and predicted concentrations. For Bowline's full-year database with only a few monitors, the test statistic used was the robust highest concentration (RHC) estimate, which was based upon the highest 25 concentrations. For the two tracer databases and the wind tunnel data base, a test statistic based upon the median of the upper quartile of the predictions and observations was used for each evaluation subset, or "regime". Three downwind distance regimes considered in the evaluation were the cavity zone (up to $3L_b$ downwind), the wake zone (from 3 to $10L_b$ downwind), and the region beyond the wake zone. Meteorological regimes chosen for the evaluation included: (1) stable conditions (stabilities 5 or 6) and the 10-m wind speed less than 4m/s, (2) unstable or neutral conditions (stabilities 1-4) and the 10-m wind speed less than 4 m/s, and (3) any stability condition with the 10-m wind speed at least 4m/s. A ratio of stack height to building height ratio of 1.25 was chosen to further divide the data into tall stack / buoyant releases versus low stack or nonbuoyant release cases. For each data set within each evaluation regime, the primary statistic was the Fractional Bias (FB), defined as:
$FB = [\,2*(C_o - C_p) / (C_o + C_p)]$, where
Co is the average of the observed concentration test statistics, and Cp is the average of the predicted concentration test statistics. The absolute fractional bias (AFB) ranges in magnitude from 0.0 for a perfect model to a value approaching 2.0 for a poor model.

The overall conclusions from the performance evaluation were (quoting the evaluation):

- "ISC-PRIME is generally unbiased or overpredicts, so its use is protective of air quality.
- ISC3 is especially conservative in stable conditions, and ISC-PRIME performs much better under these conditions. This disparity between model performance appears to be most notable for buoyant point sources. This result is consistent with the findings of other investigators.
- Under neutral conditions, the performance of the two models is more comparable, but ISC-PRIME is somewhat better. The relatively good performance of the ISC3 in neutral conditions is expected because the model was formulated based upon wind tunnel experiments carried out in neutral, high wind conditions. This results is consistent with the findings of other investigators.
- ISC-PRIME has a statistically better performance result for each data base in the independent evaluation.
- In some cases, as noted above, the use of the current ISC3 model will produce extremely conservative results under stable conditions for applications involving highly buoyant plumes."