July 27, 1988

D R A F T

ES-098

MEMORANDUM

SUBJECT: Further Comments on Modeling and Monitoring for SO_2 Emissions from the Centralia Power Plant

FROM: Robert B. Wilson
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TO: George Abel, Chief
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In this memo I want to do three things: 1) I want to provide some comments on a June 13, 1988 letter from Dick Serdoz of the Southwest Air Pollution Control Authority (SWAPCA) to you. 2) I comment on a draft revised order and variance by SWAPCA for the Pacific Power & Light (PP&L) Centralia Power Plant. And 3) I make some specific recommendations for meteorological and air quality monitoring needed to support a State Implementation Plan (SIP) revision for sulfur dioxide emissions from the Centralia Power Plant.

1. Mr. Serdoz sent you a letter dated June 13, 1988, in which he commented on my May 27, 1988 memo to you about monitoring for the Centralia Power Plant. Mr. Serdoz disagreed with my interpretation of Our March, 8, 1988 meeting, and criticized my use of a screening model to estimate impacts from the plant.

In our meeting, we (David Bray, Jon Schweiss, and myself) made it very clear that the ambient monitoring program which Mr. Serdoz was proposing at that time (consisting of two or three sites with SO_2 monitors and ten-meter meteorological towers) would not provide adequate data bases to support a SIP revision. Further, we discussed possible modifications to that proposal depending upon the objectives of the program, and to be consistent with current regulatory guidance. I maintain that we did not reach agreement on what the specific objectives of the monitoring effort were, or what the extent of the monitoring network should be. Mr. Serdoz has modified his monitoring proposal as contained in his draft revised order, and I provide comments on that in part 2 of this memo.

My previous memos to you dated November 17, 1987, and February 5, 1988, document my use of screening methods to estimate potential maximum SO_2 impacts of the Centralia Power Plant. While the analysis I did was not complete in that I did not investigate impacts on all terrain where impacts could occur, but only on Northcraft Mountain, my analysis was fully consistent with EPA's current regulatory modeling guidance, "Guideline on Air Quality Models (Revised)," EPA-450/2-78-027R, July 1986. This guidance was subjected to an extensive national public review process before being adopted as a regulation. Screening techniques are by their very nature intended to be conservative, that is, to produce estimates which are biased toward over prediction. If unacceptable impacts are indicated by the screening techniques, further refined analyses are recommended. However, further refined analyses are not possible for this source since the meteorological data available from the plant is not adequate. In the absence of data to perform refined modeling analyses, screening techniques can provide an acceptable basis for setting emission limits.

As described in my November 17 and February 5 memos, the modeling performed by PP&L as required by SWAPCA was not consistent with EPA modeling guidance. Furthermore, the modeling required by SWAPCA's draft revised order is not acceptable to EPA as discussed below.

2. In his June 22, 1988 letter to Mark Hooper, Mr. Serdoz enclosed a copy of SWAPCA's draft revised order (SWAPCA 88-934, Variance and Modification of Order) for the Centralia Power Plant. The draft order imposes a requirement for ambient air quality and meteorological monitoring, and air quality modeling to provide adequate data bases to determine whether or not SO_2 emissions from the Centralia Power Plant are causing violations of state or federal ambient air quality standards. Among other things, the draft order requires PP&L to: a) collect meteorological data adequate to model SO_2 emissions from the plant using the Rough Terrain Dispersion Model (RTDM) "or another model acceptable to SWAPCA"; b) monitor ambient SO_2 concentrations at two sites approved by SWAPCA; and c) use the measured SO_2 data to calibrate the model.

RTDM, which was discussed at our March 8 meeting, is a model that could be used for the stated purpose provided adequate on-site meteorological data was available. Adequate data is not currently available, and I discuss necessary meteorological data for RTDM in part 3 below. The use of "another" model, implying to me a non-guideline model, must be justified by a model performance evaluation, and I also discuss this further below. The important point here is in regard to the proposed calibration of a short term air quality model.

Calibration of models is addressed specifically in the Guideline on Air Quality Models, Section 8.2.11, page 8-13. In some cases, calibration of long term multi-source models may be acceptable. However,

> "Calibration of short term models is not common practice and is subject to much greater error and misunderstanding. There have been attempts by some to compare short term estimates and measurements on an event-by-event basis and then to calibrate a model with results of that comparison. This approach is severely limited by uncertainties in both source and meteorological data and therefore it is difficult to precisely estimate the concentration at an exact location for a specific increment of time. Such uncertainties make calibration of short term models of questionable benefit. Therefore, <u>short term model calibration is unacceptable</u>." (emphasis added)

Therefore, calibrating RTDM for use in an attainment demonstration as part of a SIP revision would not be approvable by EPA. In fact, RTDM must be used as specifically described in EPA modeling guidance, Supplement A to the Guideline on Air Quality Models (Revised), July 1987, pages 5-4 through 5-10.

3. To make specific monitoring and modeling recommendations, I will assume that the goal is to determine an SO_2 emission limit for the Centralia Power Plant which will prevent the plant from causing or contributing to a violation of a National Ambient Air Quality Standard or a PSD Increment. It is not feasible to use ambient air quality data exclusively for achieving this goal. There aren't adequate data available to provide justification for air quality monitor site selection. Therefore, an unreasonably large number of ambient air quality monitors would be required to provide assurance that a particular emission limit would protective of standards. As a result, air quality dispersion models must, as a practical matter, be relied upon for the demonstration of compliance.

The first objective would be to develop meteorological data bases adequate to perform a refined air quality modeling analysis consistent with current EPA guidance. In this regard, guidance in the following documents should be followed:

"Guideline on Air Quality Models (Revised)," EPA-450/2-78-027R, July 1986, including Supplement A, July 1987.

"Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)," EPA-450/4-87-007, May 1987.

"On-Site Meteorological Program Guidance for Regulatory Modeling Applications," EPA-450/4-87-013, June 1987.

"Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV. Meteorological Measurements," EPA-600/4-82-060, February 1983, (currently being revised).

Furthermore, it must be emphasized at this point that quality assurance is an extremely important aspect of an on-site measurement program. Adequate resources must be devoted to quality assurance to ensure the success of and avoid delays in the measurement program.

MPTER and RTDM - The dispersion models appropriate for this application include MPTER, for terrain at or below the tops of the stacks, and RTDM, for terrain at and above plume height. (Both models should be used for receptors on terrain between stack top and plume height.) The required meteorological inputs to these models include hourly-averaged wind speed, wind direction, temperature, stability class, and mixing height.

For this analysis, on-site wind speed and direction data will be required to adequately characterize plume dilution and transport. The measurements should be made at a height equal to the tops of the stacks. For stacks greater than 100 meters high, such as those of the Centralia Power Plant (143 meters), EPA modeling guidance allows the possibility of the measurement height being limited to 100 meters. However, in this case, data collected at 100 meters above the ground would not adequately represent the winds at plume transport height because of the terrain nearby the plant. The hills immediately north and south of the plant, comprising the boundaries of the Hanaford Valley, rise to an elevation approximately 80 to 120 meters above the stack base elevation. Thus, this nearby terrain would influence wind measurements at a height of 100 meters above the ground in a way which does not accurately represent the winds at stack top and above, affecting the plume. Therefore, stack-top wind measurements are necessary. This is particularly true in light of the fact that screening estimates have shown that impacts on more distant terrain, beyond the nearby Hanaford Valley terrain, may be critical in establishing emission limits for the plant.

In addition to winds, on-site measurements should be made for temperature and stability. Temperature should generally be measured at about two meters above the ground. Various measurements and methods are available to estimate Pasquill-Gifford stability classes. Since cloud observations are not available or feasible for this site, the preferred measurements to estimate stability class are of the standard deviations of one of three variables - the wind elevation angle, the vertical wind speed, or the horizontal wind direction (in order of preference). These measurements should generally be made at a height of ten meters above the ground.

The methods for estimating stability class from these measurements are documented in the guidance. Each of these measurement methods has some inherent problems, either in the difficulty of the measurement or in the appropriateness of the measurement as a surrogate for insolation. As a result, alternative methods for stability class estimation may be considered and approved on a case-by-case basis. Some technical justification is necessary for approval of an alternative method.

Measurement of mixing height also presents a difficult problem. Mixing height is generally estimated from temperature profile data for the lower atmosphere. Ideally for the Centralia Power Plant, the temperature profile data would be available continuously up through 2000 to 3000 meters above the surface. Temperature sensors carried aloft from the surface by balloons are the most common method for obtaining temperature profiles. Tethered balloons can routinely reach a few hundred meters above the ground, while freely-released balloons (radiosondes) can reach more than adequate heights. The data is not continuous, though, so that temporal extrapolation must be performed to estimate hourly values between the soundings. Also, capital and operating costs for one year of twice-daily radiosondes may approach $100K or more.

On-site measurements of mixing height can also be made with acoustical sounders, which can provide essentially continuous data. However, sounders are not reliable under all possible meteorological conditions. Also, sounders by themselves may not be capable of adequate data recovery (90%) from heights more than about 600 meters or so. One promising technology which is now commercially available is called RASS, for radio acoustic sounding system. This is a radar that is added on to the sodar system. The radar tracks the sound pulse from the sodar, and estimates an absolute temperature profile up through 800 meters or so above the ground. Intercomparisons with other measurement systems, as far as I know, have been limited, and there is a significant initial capital cost ($120K). However, the RASS appears to be able to produce essentially continuous temperature profile data needed to estimate mixing height, at a very low operating cost compared to balloons. While the RASS may routinely reach only 600 meters or so, I would be a lot more comfortable in this case spatially extrapolating a temperature profile upward from 600 meters, than from 100 or 200 meters.

Alternatively, one can rely on mixing height estimates from twice daily rawinsonde observations from the nearest National Weather Service (NWS) routine measurement site. Unfortunately, the nearest NWS rawinsonde site to the Centralia Power Plant is at Quillayute, Washington, over 180 kilometers to the northwest. This large distance, along with differences in topography, raise serious questions of representativeness of the Quillayute data for Centralia. Considering model sensitivity to mixing height, and the relatively high effective plume heights for the power plant, mixing height is an important model input for this analysis. Perhaps the best solution at this point is to use on-site radiosonde soundings, at sunrise and again at about 3:00 p.m.; and then supplement the soundings with measurements from an acoustical sounder, when the sounder can produce reliable data. Also, the RASS ought to be seriously investigated prior to a decision on temperature profiling methods.

Considering the above needs for input to the RTDM and MPTER models, a meteorological monitoring program for the Centralia Power Plant should consist of at least the following instrumentation to be located near the plant site:

- a three-axis doppler acoustic sounder (sodar) to measure mean wind speed and direction at stack top, and mixing height

- a 60-meter tower instrumented at three levels, 2, 10, and 60 meters to measure temperature at 2 meters, mean wind speed and direction and a standard deviation measurement for stability at 10 meters, and mean wind speed and direction at 60 meters as a constant quality assurance check for the sodar

- a radiosonde system with twice daily releases, or possibly a RASS

An alternative to the three-axis sodar would be the use of a tall tower (143 meters) to measure winds at stack top, and a single-axis acoustic sounder to get the mixing heights.

With a good quality assurance program, the above meteorological monitoring network could provide adequate data to perform a modeling analysis with RTDM and MPTER for SO_2 emissions from the plant for a SIP revision. An additional measurement of air quality may be necessary to complete the air quality analysis. Background SO_2 concentrations should be measured in an area that is representative of the area of maximum impacts of the total plant emissions. These background concentrations will be added to the maximum plant impacts to determine compliance with the NAAQS. A complete screening analysis should be performed to determine what areas may be subject to high impacts from the plant. It is probable that a site or sites could be identified to monitor background SO_2 that would represent the plant's potential high impact areas, considering the remoteness of this general area from significant SO_2 sources other than the power plant.

The above monitoring program would be considered a minimum program adequate to produce data bases for a SIP revision using current regulatory models. Because this is a significant monitoring effort, PP&L may want to consider additional monitoring that may offer the flexibility of using either a new model being developed for regulatory use by EPA called Complex Terrain

Dispersion Model (CTDM), or a non-guideline model. Below I will discuss what additional monitoring might be required for both of these cases.

CTDM - The inputs to CTDM which would require measurements beyond those required for RTDM include wind speed, wind direction, and turbulence profiles, from the surface up through plume height, and solar radiation (total or net) near the surface.

The only feasible method to get continuous wind speed, wind direction, and turbulence profiles up through plume height is through the use of a sodar. There are, however, a couple of drawbacks. First, as mentioned above, is that the data recovery rate from altitudes above several hundred meters may be less than 90 percent. There are enhancements, such as, larger antennae enclosures and dishes, and more powerful sound drivers, that can be purchased with current technology that will maximize data recovery from the higher levels. The second drawback concerns the turbulence measurements from sodars. While indications are that sodars can probably obtain reasonable estimates of vertical turbulence, that is, σ_W, the current slate of monostatic systems can not, and probably will not in the foreseeable future, be able to obtain good estimates of the horizontal turbulence, namely, σ_θ. (A major sodar intercomparison test this September in Boulder, Colorado promises to tell us much in this regard.)

It appears that the only feasible way to get σ_θ profile measurements is through the use of a tall tower located near the plant, and instrumented with fixed sensors at several levels. From a practical standpoint, the tower would probably be limited to a height of 200 meters, and the profile would have to extrapolated upward from there. This is a concern since the effective plume heights for the plant are above this height much of the time.

Temperature profiles in the lower atmosphere are needed in CTDM to determine whether or not a plume approaching a terrain feature will tend to flow up and over the terrain, or tend to flow horizontally around the terrain. Temperature profiles could be obtained from a radiosonde system, or possibly the RASS, as described above.

An instrument to measure solar radiation would be a very minor addition to the lower level of a tower near the plant.

After considering the above additional data needs of CTDM, it appears that the only additions to the MPTER/RTDM meteorological monitoring network would be extending the height of the plant-site tower to 200 meters and adding a solar radiation sensor. Minimum meteorological data requirements to use CTDM for regulatory purposes have not yet been established. However, I believe we could reach agreement with PP&L on a meteorological monitoring program that they would propose using the above guidance. Thus, the Company would have the flexibility at the end of a year's monitoring to use CTDM, if going beyond the use of RTDM was deemed appropriate.

Non-Guideline Model - Justification of the use of a non-guideline model requires a comparison of the model with a guideline-recommended model, on both a theoretical and performance basis. EPA's "Interim Procedures for

Evaluating Air Quality Models (Revised)," EPA-450/4-84-023, September 1984, should be used by the Company to develop and propose a model evaluation protocol for our review. The data bases required for a model performance evaluation can be extensive; for example, as many as a dozen air quality monitoring stations operated for one year may be necessary. In addition, continuous emissions data is essential. The meteorological monitoring required would depend upon the needs of the non-guideline model that was proposed. It is important that the monitoring network design and the model evaluation protocol be negotiated and agreed upon prior to any data collection. Examples of power plants where these model evaluation procedures have been or are being implemented are documented in "Interim Procedures for Evaluating Air Quality Models: Experience with Implementation," EPA-450/4-85-006, July 1985.

One aspect of these non-guideline model justification processes that has been observed recently is that they are taking much longer time to complete than was anticipated at their inception. Apparently some of the companies lack any incentive to stick with schedules and run a timely program. In fact, there may be any incentive to drag things out over a long period of time. I recommend that if PP&L chooses to initiate an "Interim Procedures ..." process, we establish firm milestones through some sort of legal agreement with some sort of penalties, or the automatic requirement for meeting an emission limit based on screening estimates of impacts, if milestones are not met.

There is not currently a clear need to use a non-guideline model, since there is the potential that an analysis with RTDM and MPTER may produce an acceptable emission limit. Because of this, and because adequate data to use in siting monitors does not currently exist, I expect that the Company will not initiate such a model evaluation process until the analysis using RTDM and MPTER has been completed.

I have discussed the recommendations in this memo with the Model Clearinghouse and with the Technology Transfer Work Group, which exists for the purpose of developing guidance for the use of CTDM. I have also had this memo reviewed by the Federal Land Managers - the National Park Service and the U.S. Forest Service. I would be happy to meet with you, SWAPCA, and/or the Company to discuss these matters further.

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