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DENTON,H.R. OFFICE OF NUCLEAR REACTOR REGULATION

SUBJECT: Forwards responses to NRC questions re Environ Rept-operating Lic stage.Providing info on water temp records,scale & corrosion control & thermal plume models.

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December 21, 1978
G02-78-274

Docket No. 50-397

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: WPPSS NUCLEAR PROJECT NO. 2
ENVIRONMENTAL REPORT - OPERATING LICENSE STAGE
RESPONSE TO NRC QUESTIONS

Reference: Letter, W. H. Regan, Jr., NRC, to N. O. Strand, WPPSS, dated November 27, 1978.

Dear Mr. Denton:

Washington Public Power Supply System hereby submits forty-one (41) copies of our response to the NRC questions which were transmitted with the referenced letter. Distribution is being made concurrently according to the ER-OSL distribution list provided by the NRC.

Very truly yours,

D L Renberger

D. L. RENBERGER
Assistant Director, Technology

DLR:JPC:slc

Enclosure

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RESPONSES TO NRC QUESTIONS

DATED NOVEMBER 27, 1978

IN REVIEW OF THE

WNP-2 ER-OSL

Docket No. 50-397

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

December 20, 1978

<u>SECTION 5</u>

5.17 Q. If available, provide water temperature records for the Columbia River in the immediate vicinity of the WNP-2 intake and discharge.

A. Such records do not exist.

5.18 Q. Provide current (1975-1977) records for fall chinook spawning between Priest Rapids Dam and McNary Dam.

A. Table 2.2-2 was updated with Amendment 2. The 1976 and 1977 estimates were 13,657 and 22,680, respectively.

5.19 Q. Discuss the magnitudes of natural heat loss and gains by the Columbia River near Hanford during periods of maximum river temperature (July-August). (Include estimates of solar heating, long wave losses/gains, evaporative losses/gains.)

A. The computation of energy exchange between the atmosphere and the Columbia River made use of the following equation:[1]

$$Q = \overline{Q}_{sn} + Q_{at} - Q_w - Q_e + Q_c$$

where: Q = net energy transferred into the water body from the atmosphere

$\overline{Q}_{sn}$ = average shortwave solar radiation

Q_{at} = longwave radiation emitted by the atmosphere and absorbed by the water

Q_w = longwave radiation emitted by the water surface to the atmosphere

Q_e = energy tranferred by evaporation (condensation) from the water body to the atmosphere

Q_c = energy tranferred by conduction from the atmosphere to the water body.

The values of these variables have been summarized in Table Q5.19. The assumptions or data references employed in computing these values were as follows:

[1] Daniels, D. G., and C. A. Oster, HETRAN: A Subprogram Package for Prediction of the Heat Transfer Across the Surface of a Natural Body of Water, Battelle, Pacific Northwest Laboratories, June, 1974.

1. Daily average totals of $\overline{Q_{sn}}$ were taken from the Environmental Report on WNP-2, Table 2.3-1a. These were divided by the average sunlight hours for July and August respectively to obtain average hourly daylight $\overline{Q_{sn}}$.

2. Solar altitudes (employed in determining incidence angle of shortwave radiation) were taken as the monthly average maximum value for July and August respectively. These values were adjusted for the average of 1/2 sine wave, as appropriate for a daylight average.

3. Longwave radiation from the atmosphere (Q_{at}) computation employed average monthly cloud covers, air temperatures and relative humidities (Table 2.3.1b of the Environmental Report, WNP-2). No adjustments for diurnal variations were made. Vapor pressures were determined from the CRC Handbook of Chemistry and Physics.

4. Longwave radiation from the water made use of average monthly river water temperatures at Richland (Table 2.4.4 of the Environmental Report, WNP-2) and the emissivity suggested in Reference 1.

5. Evaporation computations made use of average monthly river water densities and specific heats. Average monthly air temperatures, relative humidities, and wind speeds were employed (Table 2.3.1a, 2.3.1b, and 2.4.4 of the Environmental Report, WNP-2).

6. Conduction computations made use of the same data as No. 5.

Average $\overline{Q_{sn}}$ for a 24-hour period (as opposed to daylight hours indicated in Table Q5.19) are:

$$\overline{Q}_{sn\ July} = 95\ BTU/hr/ft^2$$

and

$$\overline{Q}_{sn\ Aug.} = 81\ BTU/hr/ft^2$$

which results in the final average daily totals of

$$Q_{total\ July} = 92\ BTU/hr/ft^2 = 2210\ BTU/day/ft^2$$

and

$$Q_{total\ Aug.} = 54\ BTU/hr/ft^2 = 1300\ BTU/day/ft^2.$$

Table Q5.19. Summary of Surface Heat Transfer Value by Process - $BTU/hr/ft^2$

	$\overline{Q}^*_{sn}$	Q_{at}	Q_w	Q_e	Q_c	Q_{total}
July	150	115	124	10.5	16.1	147
August	139	114	128	20.7	8.3	112

* Mean value during sunlight hours

5.20 Q. In the area of scale and corrosion control provide the following information:

a. Describe briefly the methods used in calculating the sulfuric acid addition, and the resulting pH value, necessary to avoid scale and corrosion. In particular, provide value of the Langelier Saturation Index which was adopted as a compromise between scaling and corrosive conditions.

b. Provide the concentration of dissolved carbon dioxide which was assumed in the above calculations. [This parameter strongly influences pH and calcium carbonate solubility. Increasing the dissolved CO_2 (carbonic acid) concentration reduces the pH and increases the solubility of $CaCO_3$, thus reducing the sulfuric acid addition necessary to control scaling of the condenser tubes. In practiced cases it is always necessary to assume a dissolved CO_2 concentration higher than would be expected in equilibrium with the partial pressure of CO_2 in normal atmospheric air. A value of 5 mg/l is often used for closed cycle cooling systems, compared to about 0.5 mg/l in equilibrium with the atmosphere at 20°C. At such low CO_2 concentrations, the solubility of $CaCO_3$ in pure water is very small, and scaling would be a severe problem.]

c. Discuss any other metals or alloys which will be used in the circulating water system, apart from the Admiralty Metal condenser tubes.

A. a. Sulfuric acid is added to neutralize just less than 100% of the "carbonate alkalinity". This results in a slightly positive Langelier's Saturation Index which is an effective compromise in the prevention of carbonate scaling and corrosion. For "maximum" hardness and alkalinity values in makeup water, a +0.5 Langelier's Saturation Index results in an operating pH of about 7.2 at five cycles of concentration and a 106°F operating temperature.

b. An equilibrium concentration of CO_2 was selected on the assumption that water dispersed in the cooling tower would lose excess CO_2 and that carbonate-bicarbonate-carbonic acid equilibria occurs rapidly with respect to water recycle times in the tower and circulating water basins.

c. Apart from the Admiralty Metal condenser tubes, circulating water will be in contact with 70/30 copper-nickel tubing, arsenical copper tube sheeting, and carbon-steel structure and piping materials.

5.21 Q. In the area of biocide additions provide the following information:

a. Will chlorine be added to the circulating water as the elemental gas (Cl_2) or as sodium hypochlorite (NaOCl) solution, as is frequently the case? [Chlorine gas is effectively converted to hydrochloric acid by reducing impurities (chlorine demand) in the circulating water and this extra acid must be considered in conjunction with the sulfuric acid added for scale control. Sodium hypochlorite solution, on the other hand, effectively adds neutral sodium chloride, with no effect on pH (provided that the hypochlorite solution does not contain excess sodium hydroxide).]

b. What materials of construction will be exposed to high concentrations of chlorine in the biocide metering system?

A. a. Chlorine will be added to circulating water as elemental chlorine. Liquid chlorine will be evaporated and the gaseous chlorine mixed in a water side stream and then pumped to a diffuser in the circulating water pump header leading to the main condenser. Acid conversion from chlorine during the anticipated (20-30 minutes) chlorination cycle per day could equate to 20 to 40% of the previously calculated sulfuric acid requirement during the chlorination interval.

b. Materials in contact with high concentrations of chlorine in the metering system include polyvinyl chloride and rubber-lined piping.

5.22 Q. Provide a table of the design parameters for the mechanical-draft cooling towers.

A. The heat dissipation system is described in Section 3.4. Most of the design parameters are given in Section 3.4.1.2. The following conditions were used for design:

Design wet bulb	60°F
Approach to wet bulb	16.3°F
Range	28°F
Circulating water flow	550,000 gpm
Drift (% of water flow)	0.05
Wind loading	100 mph
Maximum summer wet bulb	70°F
Maximum summer dry bulb	106°F

5.23 Q. Provide a detailed description of the thermal plume model used in Section 5.1.2.3. Provide all input parameters required by the model.

A. The model employed for computations leading to the analysis provided in Section 5.2.1.3 of the Environmental Report on WNP-2 solves the following partial differential equation.

$$\frac{\partial u_r T}{\partial x} = k_y \frac{\partial^2 T}{\partial y^2} + k_z \frac{{}^2 T}{\partial z^2} \qquad (1)$$

where: u_r = river velocity in the downstream direction

T = temperature

x = downstream direction

y = transverse direction

z = vertical direction

k_y = transverse mixing coefficient (assumed independent of position in x, y, z)

and k_z = vertical mixing coefficient (assumed independent of position in x, y, z)

This equation can be modified to:

$$\frac{\partial T}{\partial x} = K_y \frac{\partial^2 T}{\partial y^2} + K_z \frac{{}^2 T}{\partial z^2} \qquad (2)$$

where: $K_y = \frac{k_y}{u_r}$

$K_z = \frac{k_z}{u_r}$

if it is assumed that the river velocity, u_r, is independent of the downstream dimension (x).

The assumptions employed in reaching (1) and (2) are:

- Buoyancy effects are insignificant
- Vertical and lateral velocity components are insignificant
- Eddy diffusivities are homogeneous and spatially invariant, but possibly anisotropic (the effective eddy diffusivities need not be considered invariant if one is willing to assume that spatial gradients are small. If such an assumption is made, the equations remain as given in (2).)
- Downstream diffusion is insignificant compared to downstream advection
- The flow is steady, i.e., $\partial T/\partial t \equiv 0$
- Downstream velocity is spatially invariant in the region of the discharge.

Equation (2) has the form of the classical transient heat conduction equation and may be easily solved for any desired boundary condition using well-tested numerical techniques. For the present study, the Douglas and Gunn alternating direction implicit method was used. The finite difference formulation is as follows:

$$T^{*n+1}_{i,j} - T^{n}_{i,j} = \frac{Kx}{2}\left\{\delta_y^2\left(T^{*n+1} + T^n\right) + 2\delta_z^2 T^n\right\}$$

$$T_{i,j}^{n+1} - T_{i,j}^{*n+1} = \frac{Kx}{2} \delta_z^2 \left(T^{n+1} - T^{*n}\right)$$

where the subscripts i and j pertain to the (i, j) grid point in the y, z coordinate finite-difference network and n pertains to the point $n\Delta x$ downstream.

The difference operator δ^2 is defined by

$$\delta_y^2 T = \left(T_{i-1,\,j} + T_{i+1,\,j} - 2\,T_{i,j}\right)/\Delta y^2$$

for an evenly spaced grid.

The solution of the finite difference equations are determined by initial conditions and boundary conditions. The initial conditions consist of the temperatures throughout the cross section being simulated. The boundary conditions may be of several types. The boundary condition may be 1) at a certain temperature, 2) a heat flux boundary at which the temperature gradient is specified, or 3) a certain heat transfer coefficient may be specified (as in a convective heat transfer coefficient) with an attendant requirement for a reference off-boundary temperature. The boundary condition employed in the WNP-2 modeling was one of the second type with the flux (i.e., temperature gradient) set to zero. This is the adiabatic boundary condition.

The initial condition employed in the WNP-2 simulations was a uniform cross section ambient temperature with a region of excess temperature near the discharge point. The size of this region is such that the energy flux of the cross-sectional area is the same as the discharge energy flux. The region shape depends upon the shape of the discharge and the judgment of the modeler. The boundary geometry is selected to correspond to the actual bathymetry at the site. (Note that the bathymetry is considered not to change in the downstream direction.)

Computational stability considerations are eliminated by the use of an implicit method. However, solution accuracy requires judicious choice of grid spacing and downstream solution intervals. Poor selection of these parameters leads to numerical dispersion problems.

The model permits the use of irregular rectangular grid spacing in both dimensions of the cross section and employs a marching solution for solving the parabolic governing equations in the downstream direction.

Summarizing the required input gives the following checklist:

1) Grid selection (cross section mesh)

2) Boundary geometry and conditions

3) River velocity and eddy diffusivities

4) Initial conditions - ambient river temperatures and the size, shape, and temperature of the initial region of elevated plume temperatures

5) Initial space step in the downstream direction (it is changed as you move downstream).