UNIVERSITY OF CALIFORNIA
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A Dynamic Model for the Prediction of Wastewater Aeration Basin Temperature

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requirements for the degree Master of Science
in Civil Engineering

by
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ABSTRACT OF THE THESIS

A Dynamic Model for the Prediction of Wastewater Aeration Basin Temperature

by

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Temperature is an important factor affecting biomass activity, which in turn is critical in maintaining efficient biological wastewater treatment such as the activated sludge process. Temperature Optimization is not normally a factor in the design of aeration basins since heating or cooling of an entire wastewater stream is cost prohibitive; however, incorporating basin temperature in the design process is inexpensive and can assure a more efficient design and less operational problems under changing seasonal and influent conditions. Predicting basin temperatures can also be useful in determining the temperature effects from plant retrofits.

This thesis presents a dynamic computer model to predict aeration basin temperatures. This model can show the diurnal and seasonal changes in temperature, the effects of design and operating parameters on temperature, and the rates of heat exchange. Temperatures are predicted using plant data gathered from five wastewater treatment plants across the U.S.: Chino Basin, Terminal Island, Sacramento, Milwaukee and a pulp mill in Maine. A comparison of measured and predicted temperatures is made to verify the accuracy of the model.

Although several ssumptions had to be made to obtain a complete set of input data, the model accurately predicted temperatures in most cases within ±1°C. Applying the model to engineering situations revealed several observations:

- Surface aeration plants have a major portion of their heat loss from the aeration term whereas this is minimal in diffused aeration plants.
- Ambient temperature is a significant factor effecting several components in the heat balance.
- A sudden change in ambient temperature, such as a cold front, takes two to three days to impact the basin temperature. Therefore, operators should be aware of the potential drop in basin temperature and plant performance under these circumstances.
- Covering aeration basins seems to have a minimal effect on basin temperature of diffused systems where the ambient humidity is high, and hence, evaporation is low.

INTRODUCTION

Temperature is an important factor affecting biomass activity, which in turn is critical in maintaining efficient biological wastewater treatment such as the activated sludge process. Temperature affects the predominance of specific microorganisms as well as their metabolism. It also affects other influencing factors such as dissolved oxygen saturation and uptake rate. Optimizing for operating temperature is not normally a factor in the design of aeration basins since heating or cooling of an entire wastewater stream is cost prohibitive. Effluent quality is controlled by varying process parameters such as recycle ratio, residence time and others, which in turn determine the operating temperature range. Inaccurate temperature estimates can lead to the inability to control these other parameters sufficiently to meet effluent discharge requirements, or to overdesign of the plant. Incorporating basin temperature in the design process can assure a more efficient design and less operational problems under changing seasonal and influent conditions. Predicting basin temperatures can be just as useful in determining the temperature effects from plant retrofits. Covering aeration basins for air quality purposes and replacing existing diffusers with high-efficiency, low-energy, fine-bubble diffusers can both dramatically affect basin temperature. This model evaluates all the heat exchange components and allows the designer to manipulate various process and design variables to evaluate their effects on temperature.

This thesis presents a dynamic computer model to predict aeration basin temperatures. There are four objectives to be met in this thesis:

1. To create an accurate dynamic model by extending steady-state models that only predict a single basin temperature based on many averaged input parameters.
2. To refine the individual heat exchange equations to improve accuracy.
3. To compile these efforts into an easily used computer application.
4. To validate the model and evaluate its use.

This model can show the diurnal and seasonal changes in temperature as well as the effects of design and operating parameters on temperature. This dynamic model can also account for the rate of heat exchange. This is important because the rate at which the heat exchanges take place influences the minimum and maximum temperatures reached, which are different from those predicted by a steady-state model. The tasks involved in reaching these goals included performing a literature review, referencing these and current texts on the different heat exchange operations to refine equations where necessary, and reformulating the equations into a differential form with respect to time. Temperatures were predicted using plant data gathered from several wastewater treatment plants across the U.S. representing different climates and operating process differences. A comparison of measured and predicted temperatures was made to verify the accuracy of the model.

CHAPTER 1

BACKGROUND AND LITERATURE REVIEW

Temperature prediction models were first developed by Eckenfelder (1966), Ford et al. (1972) and Argaman and Adams (1977). These researchers relied upon earlier investigators for the various components of their models. These include the prediction of heat loss and equilibrium basin temperature for rivers and lakes (Rohwer 1931; Meyer 1942, Thorne 1951, Anderson 1954; Harbeck 1962; Raphael 1962), cooling ponds (Langhaar 1953; Thackston and Parker 1972) and aerated lagoons (Barnhart 1968; Friedman and Doesburg 1981). Most work has focused on estimating evaporation rates. Eckenfelder (1966) developed an empirical relationship, using only a single parameter, which is widely used today. More recently Ford et al. (1972), Novotny and Krenkel (1973), and Argaman and Adams (1977) have developed more comprehensive models that account for most of the heat loss/gain terms, such as evaporation, solar radiation, conduction and convection. Their models provide reasonably accurate, steady-state temperature estimates, but are tedious to perform and require a large amount of site-specific information.

Ford et al. (1972) presented a design approach for predicting temperature for activated sludge aeration basins using mechanical aerators. They used an iteration approach that includes heat loss from the aerator spray, which is calculated from the differential enthalpy of the air flowing through it. Novotny and Krenkel (1973) presented a similar approach but also provided for different evaporation rates of subsurface aeration systems.

Argaman and Adams (1977) extended Novotny and Krenkel´s model by including the terms for heat gained from mechanical energy input and biological reactions, and heat loss through the basin walls. Their model requires empirical data for determining aerator spray vertical cross-sectional area. Friedman and Doesburg (1981) tested the model of Argaman and Adams using data from eight different industrial bio-treating systems. They concluded that the temperature predicted by their model is accurate to ± 1-$3\ ^{o}$C. They conducted a sensitivity analysis to arrive at a general correlation of the heat exchange characteristics of the eight treatment systems.

This work extends directly from a steady-state model developed by Talati (1988, 1990). The Talati model incorporates the best aspects from the research previously discussed. His model improved on the accuracy of some of the calculating procedures to obtain a procedure which can be used with a minimum of background information. A search of the most recent literature produced a model by Brown and Enzminger (1991) which in most respects is identical to the Talati model. Their model uses the same set of heat gain/loss paths, with some minor differences in the exact forms of individual equations. They applied the model to the evaluation of a high strength industrial waste in above ground basins. The dynamic model presented by Schroy (personal communication, 1989) in which the equations used in describing the elements of the heat balance are derived in a differential form was also reviewed.

The Model Development section discusses each individual heat exchange component in detail. For example, much investigation of solar radiation was performed to automate the calculations and is presented and discussed in the Solar Radiation section.

Each individual section discusses the assumptions made by various researchers for individual equations and any limitations of these components.

CHAPTER 2

MODEL DEVELOPMENT

The model presented herein is applicable to a completely mixed tank under non steady-state conditions. The assumption of completely mixed tank implies uniform basin temperature at any given moment. Equation (1) is the basic energy balance equation for non-steady-state systems. This equation is derived from the generic equation for overall energy balance.

$$\rho_w V c_{pw} \frac{dT_w}{dt} = \Delta H + \rho_w q_w c_{pw} (T_i - T_w) \qquad (1)$$

where

ρ_w = density of water (kg/m^3)

V = volume of basin (m^3)

c_{pw} = specific heat of water (cal/kg ^oC)

ΔH = enthalpy change between influent and effluent streams (cal/day)

q_w = volumetric flow rate (m^3/day)

T_w = temperature of basin water (^oC)

T_i = temperature of influent stream (^oC)

The change in enthalpy is equivalent to the net gain or loss of heat (i.e., $\Delta H = Q_t$). The exchange of heat is the sum of the component equations that represent the paths of heat transfer. This is represented by equation (2) and depicted in Figure 1.

$$Q_t = Q_{sr} + Q_p + Q_b - Q_{lr} - Q_e - Q_c - Q_a - Q_{tw} \quad (2)$$

where

Q_t = net heat gain or loss (cal/day)

Q_{sr} = solar radiation heat (cal/day)

Q_p = mechanical power heat (cal/day)

Q_b = biological reaction heat (cal/day)

Q_{lr} = long wave (atmospheric) radiation heat (cal/day)

Q_e = surface evaporation heat (cal/day)

Q_c = surface convection heat (cal/day)

Q_a = aeration heat (cal/day)

Q_{tw} = tank wall heat (cal/day)

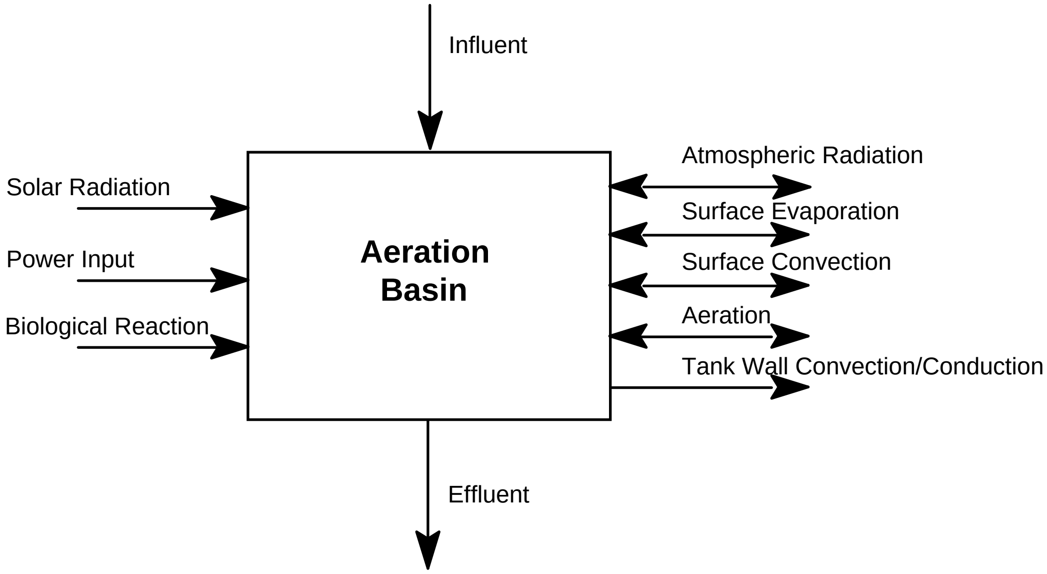

Figure 1. Heat Exchange Inputs and Outputs

The individual heat terms represent a heat exchange rate. Heat gain or loss is represented by the sign convention in equation (2) where the positive terms represent heat gains (increase in temperature) and the negative terms represent heat losses (decrease in temperature). The long wave radiation, convection, evaporation and tank wall terms can contribute either as gains or losses in which case the sign of that term will change. That is, if the value of Q_e is negative, placed in equation (2) it will represent heat gain. The expressions represented by these terms are described in detail in the following sections.

Solar Radiation

Solar radiation consists of short wave (visible spectrum) and long wave (infrared) radiation. Short wave radiation only occurs while the sun is above the horizons during daylight hours. Long wave radiation is reemitted by almost all objects and therefore persists after the sun has set (short wave radiation is not reemitted). Long wave radiation is treated separately in the next section and is referred to as long wave or atmospheric radiation; short wave radiation is referred to as solar radiation. Solar radiation can be further divided into direct beam, diffuse and reflected radiation. Heat gained from solar radiation is a function of meteorological conditions, site latitude, time of day and time of year.

Determining the solar radiation at the edge of the atmosphere is relatively easy and is mainly a function of geometry (Sellers 1965). Determining the terrestrial radiation, radiation at the earth's surface, is a function of meteorological conditions that are quite difficult to model. Expert recommendation (Blier 1992) is to use actual measured data for total solar radiation on a horizontal surface whenever possible. There are models available that calculate terrestrial solar radiation, such as that by the National Center for Atmospheric Research (NCAR 1987). This model is a complex multi-component algorithm using multiple atmospheric layers and three-dimensional analysis. For the practical purposes of this temperature model the NCAR model is much to complex, in as much as it requires data not normally available.

The method used by Talati(1988) is adapted from Thackston and Parker (1972), who used Raphael's (1962) approach. Raphael generated a curve of solar insolation versus solar altitude from data collected by Moon (1940). Prior to 1975, solar data collected by the National Oceanic and Atmospheric Administration (NOAA) was deficient (Kreider 1986, Ametek Inc. 19984). Moon's data are from independent sources; therefore the quality is not known, but also is not suspect. Moon's relationship for solar radiation is based upon a cloudless sky and a given set of atmospheric conditions: barometric pressure, depth of precipitable water, air mass, quantity of dust particles and ozone concentration, that represent what is "...characteristic of the United States and Europe" (Moon 1940). The independent variable, solar altitude, represents the effects of both time of day and time of year. Raphael presented correlations by Anderson (1954) that account for the effect of clouds on water surface reflection coefficients. These correlations are integrated in the curve presented by Raphael. Raphael's curve is presented as Figure 2 and the polynomial regression of this curve is represented by equation (3).

$$\begin{aligned} Q_{so} = (&-0.06401 + 1.3341 alt + 0.2008 alt^2 - 0.0043 alt^3 + \\ &3.79e^{-5} alt^4 - 1.37e^{-7} alt^5) 65102.26 \end{aligned} \tag{3}$$

where

Q_{SO} = clear sky solar radiation (cal/day)

alt = solar altitude (degrees)

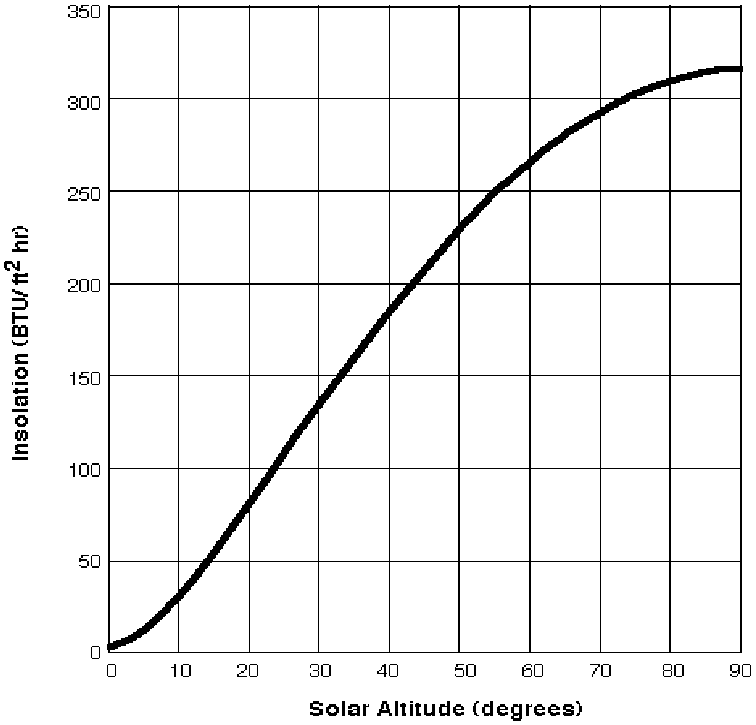

Figure 2. Terrestrial Solar Radiation

The direct effect of cloud cover on solar radiation is presented as a separate empirical equation, given by equation 4.

$$Q_S = (1\text{-}0.0071\ CC^2)\ Q_{SO} \tag{4}$$

where

CC = cloud cover (0-10)

It is important to note the assumptions made in equations (3) and (4). Moon's data for the relationship of solar altitude to radiation are derived from specific empirical equations developed from a single data set. It is also verified against a single data set. The effect of atmospheric conditions, apart from clouds, is generalized. The effect of cloud cover on water surface reflectivity is also generalized.

The solar altitude is not usually measured directly and must be determined from other known angles. The equations for determining those angles and the value of Q_S are presented in Appendix B.

Long Wave (Atmospheric) Radiation

The heat exchange from longwave radiation is based on the Stefan Boltzman's fourth power radiation law. The net effect of long wave radiation is the difference between incoming and back radiation as expressed by equation (5).

$$Q_{lr} = \left[\varepsilon\sigma(T_w + 273)^4 A_s\right] - \left[(1-\lambda)\beta\sigma(T_a + 273)^4 A_s\right] \tag{5}$$

where

ε = emissivity of the water surface (0.97)

σ = Stefan Boltzman constant [1.17×10^{-3} cal/(m^2 day K^4)]

λ = reflectivity of water surface (0.03)

β = atmospheric radiation factor

T_a = ambient air temperature ($^{\text{o}}$C)

The atmospheric radiation factor β, is a function of cloud cover, cloud height and vapor pressure. Raphael (1962) modified the empirical equations for beta, developed by Anderson (1954), to disregard cloud height. This produced a series of lines for different cloud covers. Talati (1988, 1990) determined the slope and intercept of each line and then required that beta be evaluated by picking values from this Table and evaluating the linear equation. A polynomial curve was fitted to the slope and intercept terms in the equations that represent the individual cloud cover lines. This produced the following equations for beta and its coefficients.

$$a = 0.7399300762 + 0.010352672786CC - 1.9812639499e^{-5}CC^2 \tag{6}$$

$$b = \left(0.14729812741 - 5.6951848819e^{-5}CC^3\right) \div 10 \tag{7}$$

$$\beta = (a + b\nu_a)0.5357756 \tag{8}$$

where

ν_a = vapor pressure of water at air temperature (cal/kg)

The data Anderson used to make his correlations were obtained from a study performed in a cooler climate. The data are generally below a vapor pressure of 25 millibars (0.75 in. Hg). Raphael's graph is plotted up to 1.0 in. Hg, and in doing so, he has performed an extrapolation on Anderson's data. In warmer temperatures, the corresponding vapor pressure can be even higher than 1.0 in. Hg, which would require even further extrapolation of Anderson's data. The effect of a changing β, including the extrapolated range, on atmospheric heat and final temperature, all other things being equal, was evaluated.

The effect of β in the heat equation is linear, as is the heat term in the evaluation of basin temperature. An evaluation of the numerical effect of changing β is, therefore, reduced to determining the slope of the line and observing what kind of influence this rate of change exerts. β can be expected to range from approximately 0.75 to 1.05. For β versus the heat quantity, the rate of change is -2.65×10^9 cal/day/1.0$\Delta \beta$; therefore it is a significant effect on the heat exchange with respect to beta. The basin temperature has a rate of change of 0.19 $^{o}C/\Delta \beta$, which over the expected range, translates to a 0.057 degree temperature difference. Although this does not imply anything about the validity of extrapolating, it does indicate that to extrapolate beyond the last data value (approximately 0.94) up to a generalized maximum of 1.05 would change the temperature by only 0.02 degrees.

The assumption that this extrapolation is valid as well as the assumptions of β's empirical basis are accepted for this model. The values of emissivity ε, and reflectivity λ, are 0.97 and 0.03, respectively.

Surface Convection

Heat transfer from surface convection is driven by the temperature difference between the water and the air above it. It is also influenced by the vapor transfer coefficient, which is a function of wind velocity. Equation (9) was developed by Novotny and Krenkel (1973) and modified to this final form by Talati (1988, 1990).

$$Q_c = \rho_a c_{pa} h_v A_s (T_w - T_a) \qquad (9)$$

$$h_v = 392 A_s^{-0.05} W \qquad (10)$$

where

h_v = vapor phase transfer coefficient

ρ_a = density of air (kg/m^3)

c_{pa} = specific heat of air (cal/kg ^{o}C)

W = wind velocity at water surface (m/sec)

The limitations in this equation are those of the polynomial regressions representing the physical properties. The equation for density of air is valid for -50 to 60 ^{o}C, the specific heat of air is valid for 0 to 100 ^{o}C.

Evaporation

Heat transfer by evaporation is a function of the water and air temperature difference, wind velocity and humidity. Talati (1988, 1990) used an equation developed by Novotny and Krenkel (1973) which has not been changed.

$$Q_e = [1.145 \times 10^6 (1 - r_h/100) + 6.86 \times 10^4 (T_w - T_a)] \exp(0.0604 T_a) W A_s^{0.95} \qquad (11)$$

where

r_h = relative humidity (%)

Aeration

Heat exchange from aeration consists of two components: sensible heat loss in the form of convection, and latent heat loss in the form of evaporation. The quantities of heat, the proportion of convective to evaporative heat exchange, and the exact form of the governing equation, are dependent on the type of aeration; either surface or diffused. The total heat exchange from aeration is the sum of the sensible and latent components, equation (12).

$$Q_a = Q_{as} + Q_{al} \tag{12}$$

where

Q_{as} = sensible heat exchange

Q_{al} = latent heat exchange

The sensible or convective heat exchange for surface aeration is given by equation (13).

$$Q_{as} = \rho_a c_{pa} h_v A_s (T_w - T_a) c_{time} \tag{13}$$

$$h_v = 392 N F^{-0.05} W \tag{14}$$

where

N = number of aerators

F = aerator spray area (m^2)

c_{time} = conversion factor for time = 86,400 seconds/day

Note the difference in the vapor phase transfer coefficient as compared to its use in surface convection. In this case the basin surface area is replaced with the aerator spray area multiplied by the number of aerators. In Talati's use of the coefficient, the number of aerators was missing in the model and the program as well. The aerator spray area must be determined experimentally or obtained from the manufacturer. The spray area for one manufacturer's low speed mechanical aerator as a function of aerator power is shown in Figure 3 (Mixing Equipment Co., personal communication, Sept. 1988).

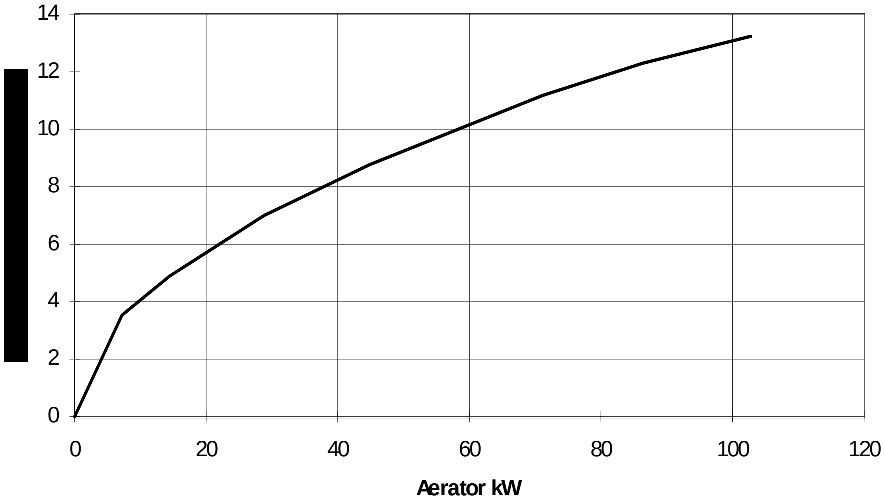

Figure 3. Spray area for low-speed mechanical aerators.

The overall equation for heat exchange contains the basin surface area A_S. To be exact, this term should theoretically be the surface area of all water droplets in the spray. This area would be difficult to determine experimentally and the basin surface area, A_S, is used as a surrogate. In the case of diffused aeration systems, the vapor phase transfer coefficient is simply replaced with the airflow rate, as shown in equation (15).

$$Q_{as} = q_a \rho_a c_{pa} (T_w - T_a) c_{time} \tag{15}$$

where

q_a = air flow rate (m^3/sec)

The second component of the aeration heat exchange is the evaporation, or latent heat, term. This equation was developed by Novotny and Krenkel (1973) and modified to this final form by Talati (1988, 1990). It is used without further modification and is given by equation (16).

$$H_{al} = \frac{M_w q_a L c_{time}}{100 R} \left\{ \frac{v_w \left[r_h + h_f (100 - r_h) \right]}{(T_w + 273)} - \frac{v_a r_h}{(T_a + 273)} \right\} \tag{16}$$

where

M_w = molecular weight of water

L = latent heat of vaporization (cal/kg)

R = universal gas constant (62.361 mm Hg-l/gmole K^4)

v_w = vapor pressure of water at basin temperature (cal/kg)

v_a = vapor pressure of water at air temperature (cal/kg)

h_f = exit air humidity factor

For surface aerators the gas flow rate must be estimated from the spray area and wind velocity as shown in equation (17).

$$q_a = NFW \tag{17}$$

The exit air humidity factor is a measure of the humidity of the air that exits through the aerator spray area. In subsurface systems the gas has a longer contact time and is assumed to be saturated as it reaches the surface of the basin, and h_f is assumed to be 1.0. For the surface aerators, the contact time is less and the factor is less than 1.0. Values used were obtained from Talati, who empirically fitted this parameter to the data analyzed in his study.

The limitations and assumptions associated with aeration heat exchange are those discussed above concerning the use of basin surface area in the surface sensible exchange term, the use of the empirical constant for exit air humidity factor, and the inherent limitations on the regressions of the physical property parameters. The latent heat of vaporization were regressed over the range 0 to 180 ^{o}C and v_w on the -15 to 40^{o}C range.

Power Input

Surface aerators are partially submerged in the basin and are in direct contact with the liquid. Hence, all the mechanical energy supplied to the impellers is available in the form of heat energy to the wastewater. The energy is initially in the form of kinetic energy, but is transformed to heat energy before it leaves the basin (i.e., flow in and out are considered equal). In diffused aeration systems, heat is added to the air stream in the process of compression. The heat added is represented by the inefficiency (one minus the efficiency), which is the energy wasted in the form of friction that will heat the air stream. As the gas rises through the liquor and expands it will also cool, therefore not all this heat is available for sensible transfer. Surface aerators transmit all their shaft power into heat energy. These are represented by the equations given below.

Subsurface aeration:

$$H_p = c_{hp} P \,(1- \eta/100) \tag{18}$$

Surface aeration:

$$H_p = c_{hp} P \,(\eta/100) \tag{19}$$

where

c_{hp} = conversion factor for horsepower to calories (1.54×10^7 cal/day./hp)

P = WIRE horsepower

η = efficiency (%)

Biological Reaction

Biological reactions provide heat to aeration basins because such reactions are exothermic in nature. Heat released from a biological reaction process depends upon the composition of wastewater, the mass of organics removed and the cellular yield. Argaman and Adams (1977) assumed a cell yield of 0.25 grams volatile suspended solids (vss)/gram of chemical oxygen demand (COD) removed. This model allows for the introduction of a specific cell yield. This is represented by equation (20).

$$H_b = (3.3 - 5.865y)\Delta S \tag{20}$$

where

y = cell yield (g of VSS/g of COD)

ΔS = substrate removal rate (g of COD/day)

Conduction Through Tank Walls

Heat is lost from conduction and convection through tank walls and bottom. Municipal aeration basins are often below ground and industrial basins are often above ground, while some basins are a combination. The heat transfer coefficients for concrete to air and concrete to earth are different. Therefore, this model has included two terms: one for submerged wall area exposed to air and one for submerged area exposed to the ground. The ground term should also include the area of the basin bottom. Figure 4 illustrates this arrangement. The governing equations are given by equations (21) and (22).

Exposed to air:

$$H_{tw} = U_a A_w (T_w - T_a) \tag{21}$$

Exposed to ground:

$$H_{tw} = U_g A_g (T_w - T_g) \tag{22}$$

where

U_a = overall heat transfer coefficient for conduction to air (cal/day m^2 ^{o}C)

A_w = area exposed to air (m^2)

U_g = overall heat transfer coefficient for conduction to ground (cal/day m^2 ^{o}C)

A_w = area exposed to ground (m^2)

T_g = temperature of the ground (^{o}C)

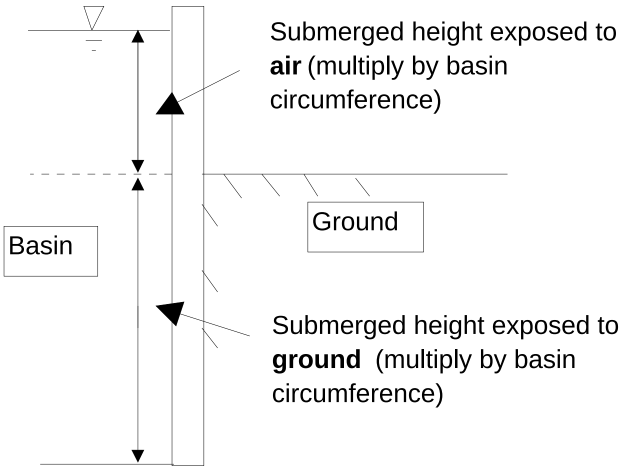

Figure 4. Basin wall contact diagram.

Determination of overall heat transfer coefficient is analogous to electrical resistance equations, and the approach used by ASCE (ASCE 1959) is used herein, as equation (23).

$$U = \frac{1}{\frac{1}{K_i} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \ldots. + \frac{1}{K_o}} \tag{23}$$

where

x_1,x_2 = thickness of materials (inches)

k_1,k_2 = thermal conductivity of materials (BTU/hr ft^2 ^{o}F inch)

K_i = surface conductance at the air-surface area inside tank (BTU/hr ft^2 ^{o}F)

K_o = surface conductance at the air-surface area outside tank (BTU/hr ft^2 ^{o}F)

The factor 1/K_i becomes zero if liquid is touching the surface of the wall (there would be a portion of wall in contact with gas in the case of a enclosed digester). If the outside wall is in contact with air an approximate value of K_o is taken as 6.0 BTU/hr ft^2 ^{o}F. If the wall is surrounded by an earth embankment greater then 10 ft. thick, K_o becomes 1.0. Typical values for thermal conductivity are listed below, Table 1.

Table 1. Thermal conductivity for common construction materials.

Material	**Coefficient**
Air space	1.1
Brick masonry	5
Cinder Concrete	5.4
Concrete Blocks	0.8 to 1.0
Concrete	12
Soil (dry)	8
Soil (wet)	16

The heat exchange equation requires the overall coefficient in SI units; therefore the result of equation (23) must be converted to SI units.

Integration Technique

The energy balance equation for this non-steady-state system, equation (1), must be solved for T_W. Once all the individual heat exchange equations described in the previous sections are summed together as shown by equation (2), the overall equation is quite complex. An analytical solution would be difficult, so numerical integration is used to solve for T_W. A second-order Euler integration method is used. Equation (1) is solved for dT_W/dt, which can then be evaluated. This value is then used to generate a temperature value corresponding to one-half the chosen timestep. The new value is used as the initial value in determining the individual heat exchange terms and a new value of dT_W/dt is generated, which can then be evaluated at a full timestep. This procedure is can be written in the following general form.

$$T_{\frac{1}{2}} = T\big|_t + \frac{\Delta t}{2}\frac{dT_w}{dt}\bigg|_t \tag{24}$$

$$T = T\big|_t + \Delta t\frac{dT_w}{dt}\bigg|_{t+\frac{\Delta t}{2}} \tag{25}$$

The initial conditions must be supplied and in this case is the initial basin temperature. This procedure has the benefit of always converging. The length of time required to converge depends on the initial conditions. This model incorporates an iterative substitution technique to solve for the initial condition, based upon an initial "given" basin temperature. However, the iterative procedure can diverge if its initial "given" is too far off. The initial temperature can sufficiently approximated by using an average influent temperature value. This will be adequate for the iterative solution to converge. By supplying the numerical technique with this value, the numerical integration output will then reach convergence quickly.

CHAPTER 3

PROGRAMMING

Main Program

The main program is the portion that performs heat exchange calculations and numerical integration. The program consists of the main routine and four subroutines; all are written in FORTRAN 77. The main routine reads in all the data files and writes the data to an output file which can then be checked for correctness. The main routine then calls the subroutine INIT, which determines the equilibrium temperature from the initial conditions which is then used as a starting value for the dynamic program. The main routine then performs the second-order numerical integration. This consists of calling the subroutine SUMH which calculates the slope as described in Chapter 2 - Integration Technique, calculating the temperature at one-half timestep, calling the subroutine with the new input temperature and then calculating the final timestep temperature. Second-order Euler integration was used to integrate the equation.

Subroutine SUMH contains the heat exchange equations described in Chapter 2. These equations are summed and the rate of change of temperature with respect to time is calculated as described in Chapter 2 - Integration Technique. The subroutine SUMH calls a subroutine called SOLAR, which calculates the clear sky solar radiation when no data is supplied by the user. SOLAR also calculates the rise and set times of the sun using a subroutine function, TIMEFTN, which returns the hours from the supplied datetime data parameter. SUMH also calls a subroutine called AFGEN which is used on all the data array parameters. As the program increments the timestep and performs numerical integration, the time value used for calculations may be intermediate to the times supplied in the input arrays. AFGEN linearly interpolates between the supplied data points to return the required intermediate values. Appendix C contains the code for the main program.

Input/Output (I/O) Operations

I/O operations are performed by an EXCEL (Microsoft Corp. 1992) spreadsheet program. The input data files can be created manually with any text editing program. The EXCEL program is a macro driven spreadsheet developed to simplify data entry and allow for viewing and plotting data output. Upon starting the EXCEL program, the user is presented a menu bar containing two menu items; Data and Options. Selecting Data will allow you to enter or edit data into the spreadsheet forms, view the output data, or produce a graph of the output data. Options allows you to run the modeling program, clear the entry fields (except for the date and time columns), exit the spreadsheet or bring the EXCEL default menu back.

The date format the program requires must be calculated as the day of the year with time of day as a decimal fraction. The local time used for that calculation must first be converted to Greenwich Standard Mean Time (GSMT). The spreadsheet will perform all these necessary calculations, and is thus the preferable method of data entry. The spreadsheet will also recalculate the local time since the program output will be in GMST. The various options not described are self explanatory and the system will generally prompt for responses.

CHAPTER 4

MODEL RESULTS

Introduction

The ability of this model to predict accurate temperatures in aeration basins is validated by running the model with all required input data and comparing the output to the actual measured temperature values. Five wastewater plants across the country were solicited for their help with this project. A questionnaire was sent to each plant requesting all necessary operating data and plant design information. This information was requested for the months of July 1991 and January 1992. Summer and winter months were selected to evaluate two extremes of ambient conditions. A summary of the plants analyzed in this study is presented in Table 2.

The input data required for the model consists of time invariant data that falls into three groups: site-specific data, process data and modeling information. Some of the parameters may vary with time, but have been approximated to constants for this model. There may be some parameters that do not apply for certain plants and an appropriate value (i.e. zero) needs to be entered for consistency in the input file. These parameters, as they are presented in the data entry spreadsheet form, are listed in Table 3.

The remaining input data varies with time. Not all of these parameters will apply to all plants since there is input for both surface and diffused plants and optional input for solar radiation. In these cases input files with zero values need to be generated for each parameter to satisfy the program read statements. There are five meteorological parameters in this list (Table 4): ambient temperature, relative humidity, wind speed, cloud cover and solar radiation. This information was ordered from the National Climatic Data Center (NCDC) in Ashville, North Carolina. Solar radiation can be calculated by the model, but can also be measured directly; therefore this option is made available. Meteorological data were requested on an hourly basis to increase the accuracy of these input parameters. Plant operating data are rarely available on an hourly basis and are generally presented as daily values, as was the case for all data gathered in this study.

Validation

Validation is performed by running the model with all required input data and comparing the output to the actual measured temperature values. For each of the five plants evaluated, it was necessary to make various assumptions to obtain a complete set of input files. Often, only BOD data were available; COD removal is the preferred model input. Assumptions have been made to convert BOD to COD in these situations. The potential error in making many of the assumptions is negligible as seen in the discussion of temperature prediction sensitivity to parameter change later in this chapter.

Milwaukee

The evaluation of the South Shore WWTP in Milwaukee was one in which assumptions of higher confidence where used to create a complete set of input data. This plant treats approximately 100 mgd of wastewater with primary clarification, activated sludge process and final disinfection. The unit process sizes and quantity are described in Table 2.

Table 2. Treatment Plant Summary

	Plant	Location	Approx. Capacity	Aeration Type	Primary Clarifiers	Aeration Basins	Secondary Clarifiers
1	South Shore WWTP	Milwaukee, Wi.	100 mgd	Diffused	16 - 40' x 160' x 10'	28 - 370' x 30' x 15'	24 - 112' dia. x 14.75'
2	Chino Basin Regional Plant 1	Chino, Ca.	15 mgd	Surface	10 - 175' x 20' x 11' 1 - 100' dia. x 9'	3 - 240' x 130' x 17.8'	4 - 120' x 14' 2 - 130' x 4'
3	Terminal Island Treatment Plant	Los Angeles, Ca.	20 mgd	Diffused	6 - 250' x 20' x 12'	9 - 300' x 30' x 15.14'	18 - 150' x 200' x 12'
4	Pulp Mill	Maine	35 mgd	Diffused	1 - 220' dia. x 15'	Irregular shape area=96,626 ft2 12-12.5' deep	3 - 290' x 65' x 15'
5	Sacramento Regional Treatment Plant	Sacramento, Ca.	200 mgd	Diffused-HPO	12 - 1170 gal/ft^2 day	8 trains of 4 basins basin - 48' x 48' x 30'	16 - 130' dia.

Table 3. Time Invariant Parameters

Parameter	**Units**
Site-specific data	
latitude of site	degrees
longitude of site	degrees
ground temperature	^{o} C
Process data	
basin surface area	m^{2}
basin volume	m^{3}
submerged wall area exposed to air	m^{2}
heat transfer coefficient to air	cal/m^{2}/day/^{o}C
submerged wall area exposed to ground	m2
heat transfer coefficient to ground	cal/m^{2}/day/^{o}C
power input to aerator	hp
efficiency of aerator	%
power input to compressor	hp
efficiency of compressor	%
cell yield	g VSS/g COD
Modeling information	
start date and time	m/d/yy h:mm
duration of run time	days
print time interval	h:mm
initial basin temp. estimate	^{o}C

Table 4. Time Variant Parameters

Parameter	**Units**
Aerator Spray Area	m^2
Air Flowrate	m^3/sec
Air Temperature	^oC
Cloud Cover	1 to 10
Influent Flow	m^3/day
Influent Temperature	^oC
Number of Aerators	
Relative Humidity	%
Solar Radiation	cal/day
Substrate Removal Rate	kg COD/day
Wind Speed	m/sec

Input data for the months of July 1991 and January 1992 are listed in Appendix D. Several assumptions had to be made to complete this data set.

- Ground temperature, required for the losses through the walls and floor, was estimated based on the ambient temperature.
- The number of basins in service varies (18 to 19 in January, 19 to 24 in July), an average number of basins was used for calculating basin volume and surface area.
- The wall area exposed to the ground is assumed constant, although varying the number of basins in service changes the total area exposed to the ground.
- COD is not measured, BOD data were converted using historical values for COD/BOD ratios (2.5 in influent, 5.0 in effluent).

- In calculating the cell yield, the TSS was multiplied by 0.7 (an approximation of VSS/TSS ratio for longer sludge age), and the calculated COD values were used.
- Compressor efficiency was an assumed value.
- Plant influent temperature, not aeration basin influent temperature, was supplied. No corrections were made.
- Plant effluent temperature, not aeration basin effluent temperature, was supplied. Secondary clarifier and chlorine contactor areas were used to adjust for temperature change due to evaporation, convection, long wave and solar radiation.

A comparison of predicted to measured temperatures for January and the residual difference between the predicted and measured values are shown in Figures 5 and 6, respectively. The predicted values and residual for July are shown in Figures 7 and 8. January and July both show excellent fit for the predicted values; the residuals are mostly in the ±1 ^{o}C range. The actual measured values for this plant were given in 1 ^{o}F intervals, suggesting that the accuracy of the actual measurements are only ±1 ^{o}F (±0.55 ^{o}C).

Sacramento

Sacramento is a high-purity oxygen (HPO) activated sludge plant. The unit process sizes and quantity are described in Table 2. The aeration basins are necessarily covered in this plant. This required some modifications to the program code. There is no longwave radiation, solar radiation, evaporation or convection from the surface. In this case, the meteorological terms are required to adjust for the secondary clarifiers and no other terms are available to cancel out these components. Therefore, these lines were deleted from the code. The sensible heat exchange is effected only by the flow of oxygen gas leaving the system, whereas the latent heat (evaporation) is effected by the entire gas flow leaving the system. This adjustment was placed directly in the code. A comparison of predicted to measured temperatures for January and the residual difference between the predicted and measured values are shown in Figures 9 and 10, respectively. The predicted values and residual for July are shown in Figures 11 and 12. January and especially July both show excellent fit for the predicted values.

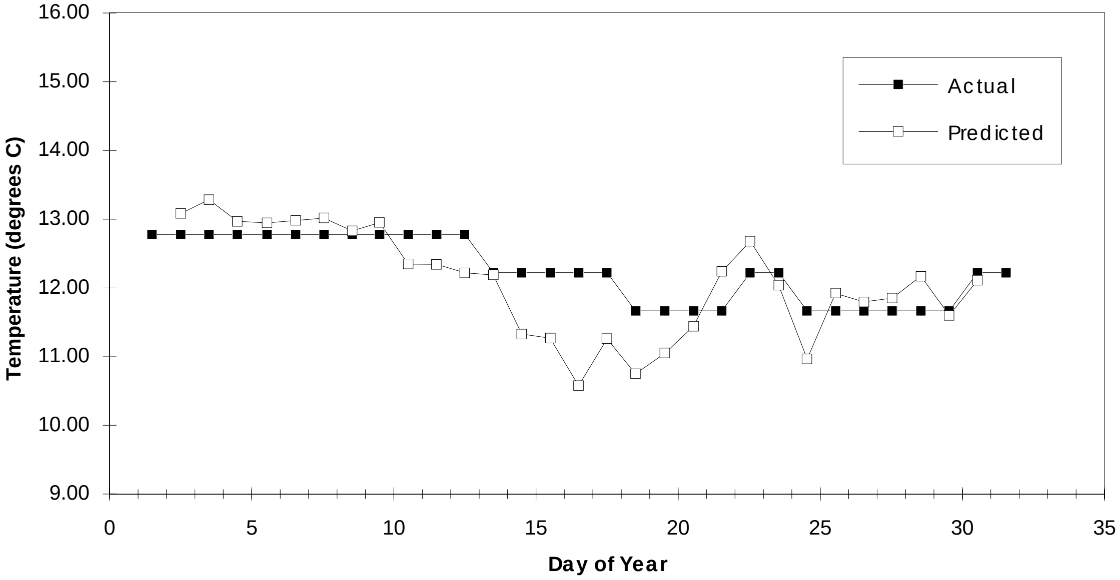

Figure 5. Milwaukee - January Temperature Prediction

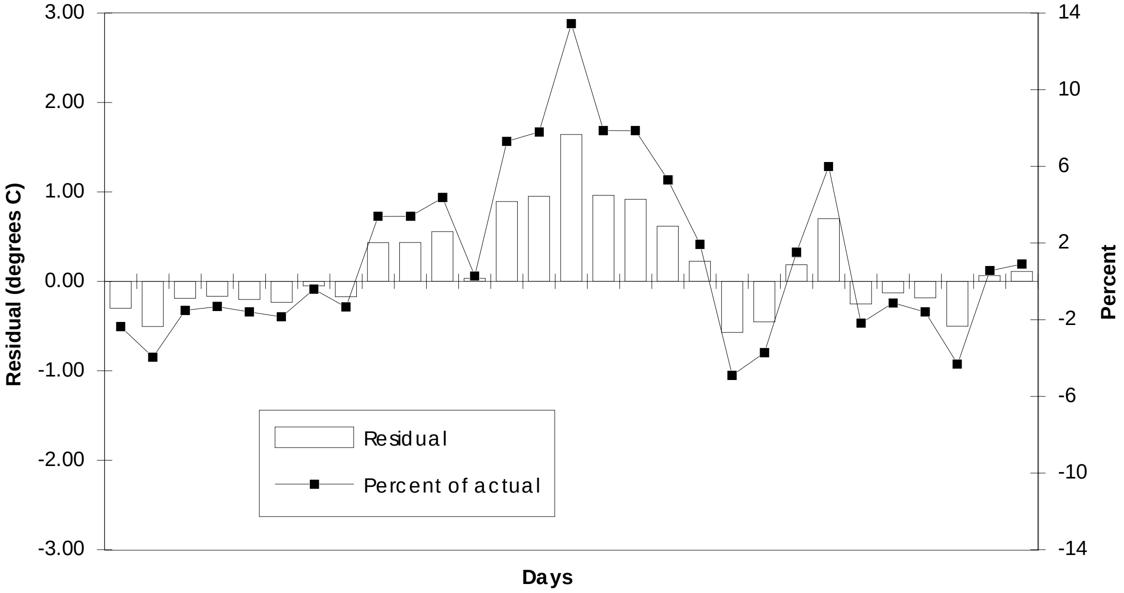

Figure 6. Milwaukee - January Actual/Predicted Residuals

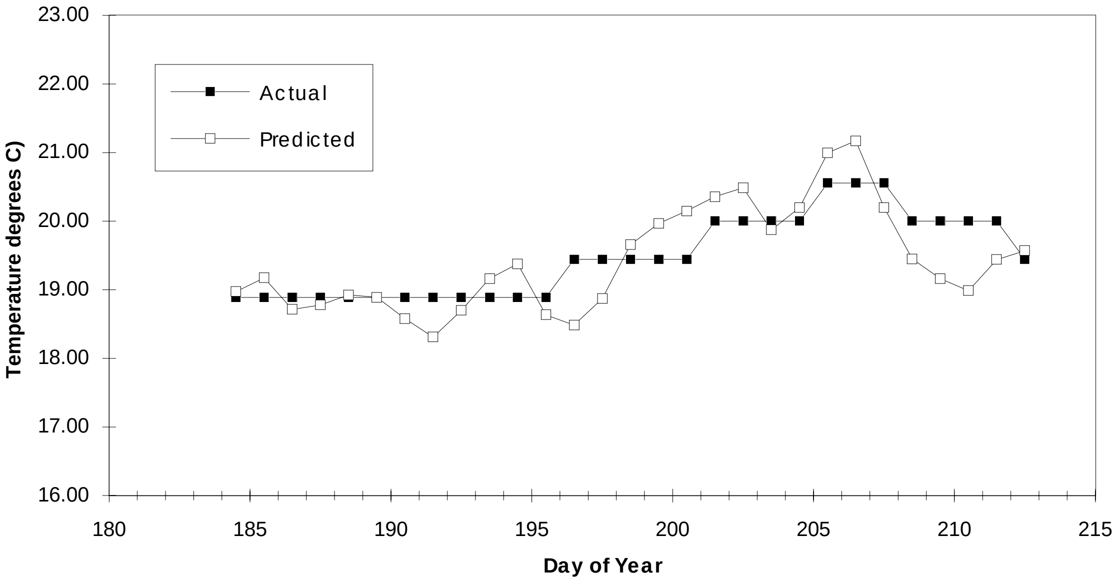

Figure 7. Milwaukee - July Temperature Prediction

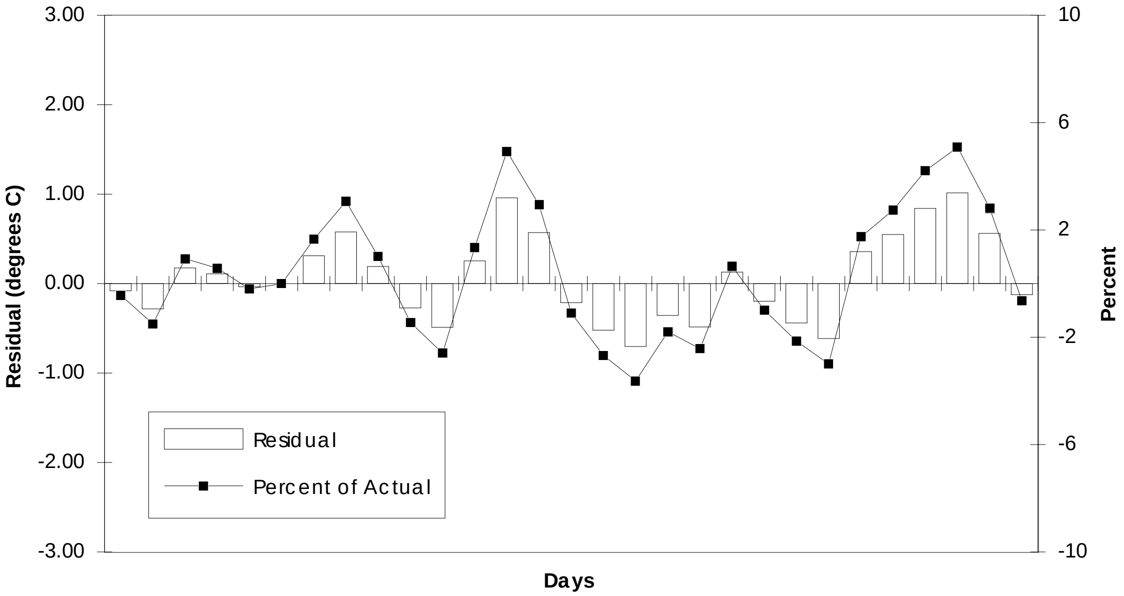

Figure 8. Milwaukee - July Actual/Predicted Residuals

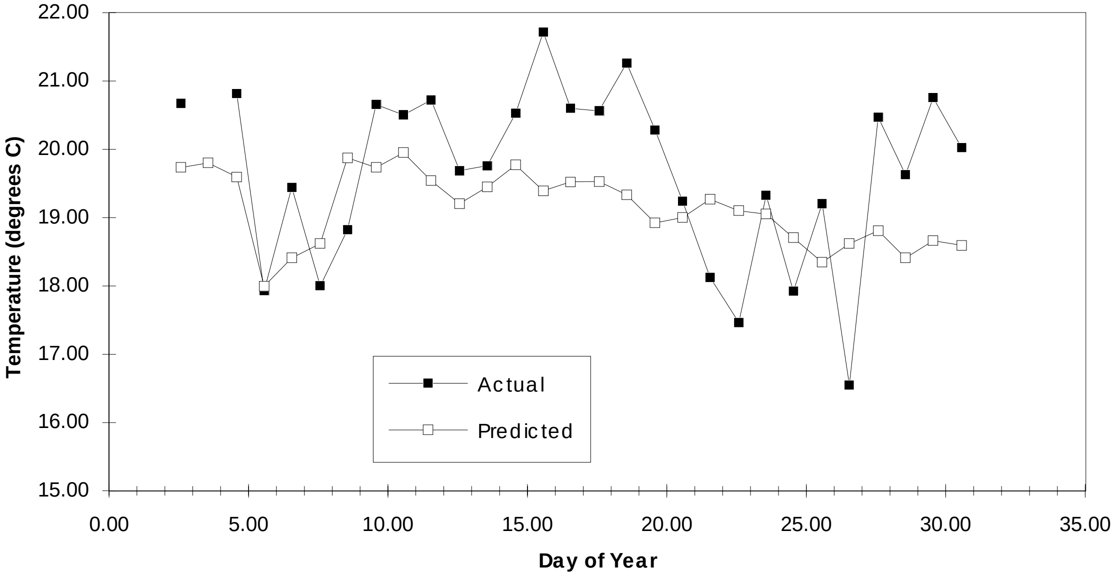

Figure 9. Sacramento - January Temperature Prediction

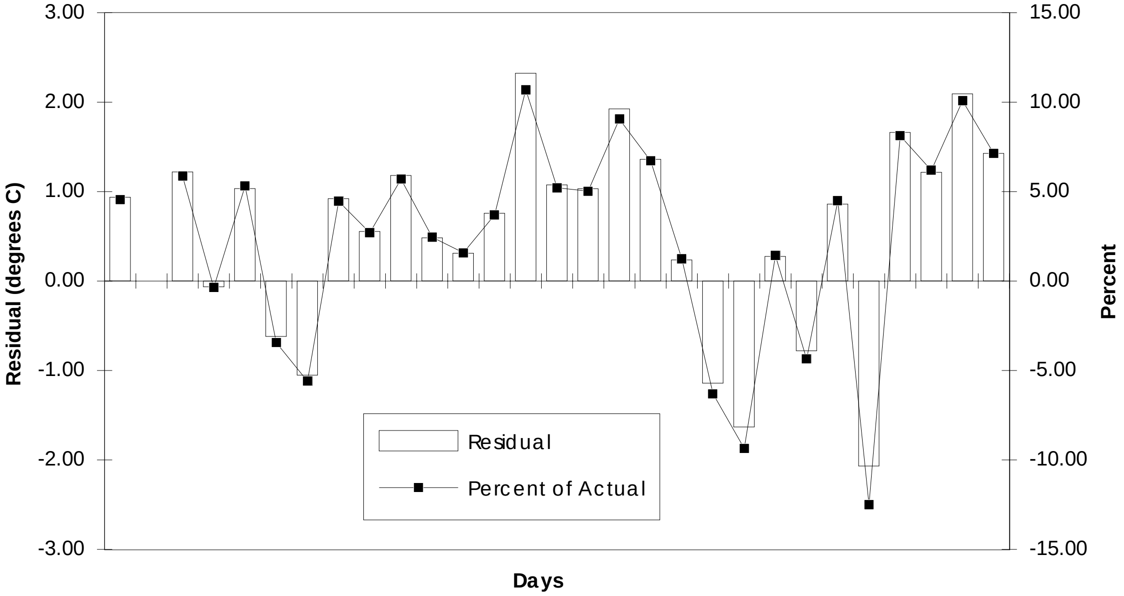

Figure 10. Sacramento - January Actual/Predicted Residuals

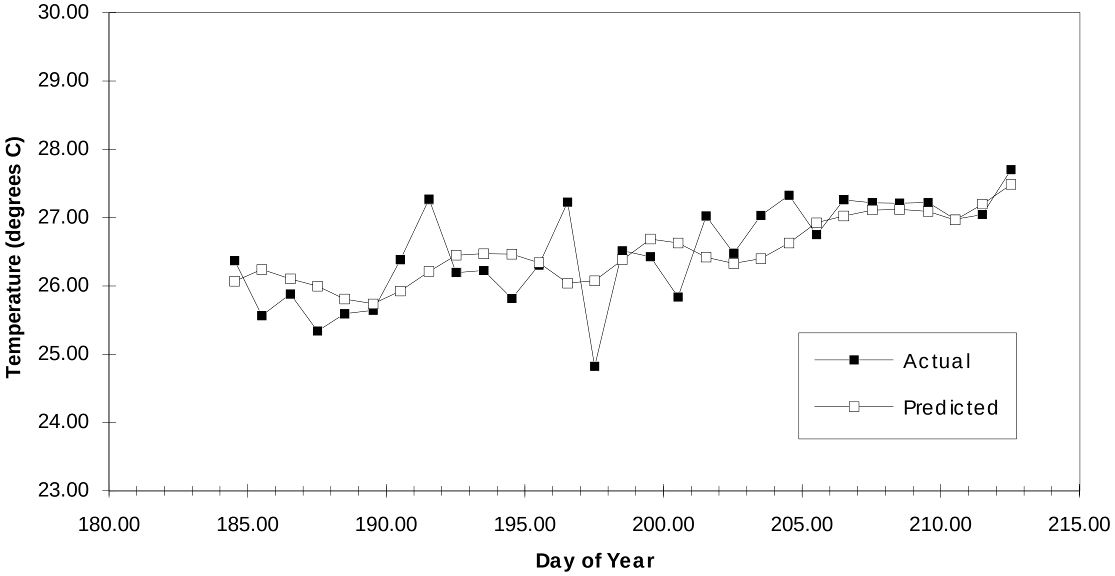

Figure 11. Sacramento - July Temperature Prediction

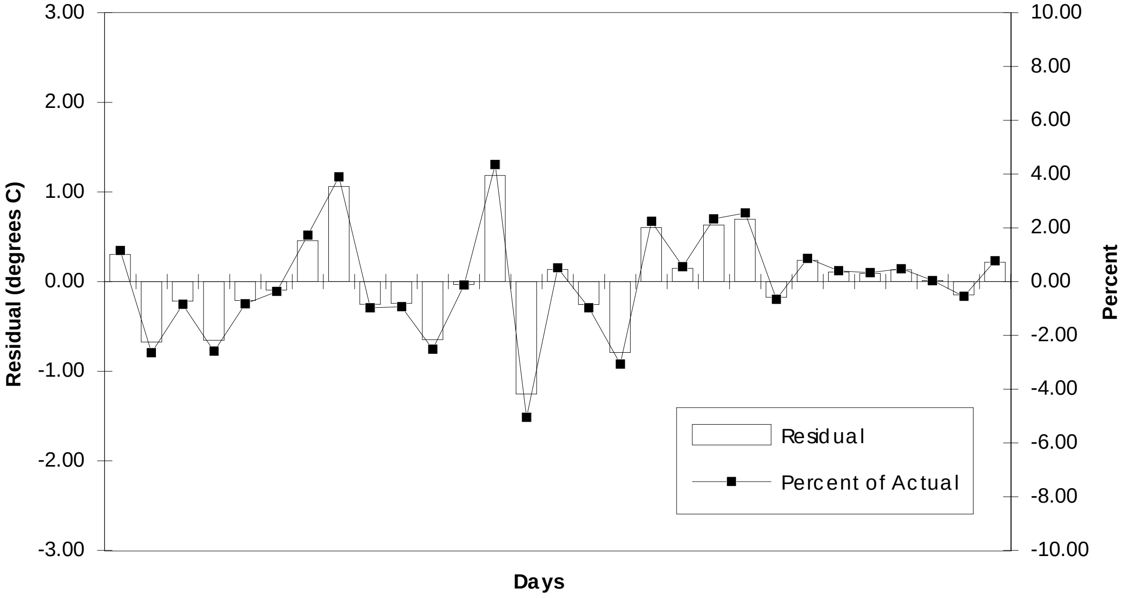

Figure 12. Sacramento - July Actual/Predicted Residuals

Chino Basin and Terminal Island

Neither of these plants measures influent temperature, which is a critical input parameter. To produce a complete data set a constant influent temperature was assumed for the input, and various temperatures were evaluated by trial and error to produce the best fit. Both plants are otherwise excellent examples as few additional assumptions were needed. Ground temperature, compressor/aerator efficiency and VSS/TSS conversion were the only other assumptions made. Predicted temperature and residuals for both months and plants are shown in Figures 13 to 20. The influent temperature was necessarily set to a constant and the fits would probably be even better had this information been available. The unit process sizes and quantity are described in Table 2.

Pulp Mill

This plant treats approximately 35 mgd of wastewater with primary clarification, activated sludge process and final disinfection. The unit process sizes and quantity are described in Table 2.

Input data for the months of July 1991 and January 1992 are listed in Appendix D. Several assumptions had to be made to complete this data set.

- Ground temperature, required for the losses through the walls and floor, are estimated based on the ambient temperature.
- The basin floor is earthen and walls are concrete, details and the exact construction are unknown. The heat transfer coefficient was estimated.

- COD is not measured, BOD removal data was converted to COD removal (values ranged from 1.5 to 3.5) based upon literature references (DeLorme 1990).
- Compressor efficiency was assumed.
- Plant influent temperature, not aeration basin influent temperature, was supplied. No corrections were made.
- Plant effluent temperature, not aeration basin effluent temperature, was supplied. Secondary clarifier and chlorine contactor areas were used to adjust for temperature change due to evaporation, convection, long wave and solar radiation.

The initial run on this data set produced temperatures that were 2-3 ^{o}C high. Inspection of the heat proportions showed a large contribution from biological heat. The estimate for the COD/BOD ratio of 2.5 was reduced 1.5 and the subsequent run produced high temperatures as well. Since the closest location for meteorological data was from a location approximately 100 miles from the plant, this data was adjusted to try and account for the changes. The ambient temperature and relative humidity were adjusted based on communications with plant personnel.. This adjustment produced excellent results. A comparison of predicted to measured temperatures for January and the residual difference between the predicted and measured values are shown in Figures 21 and 22, respectively. The predicted values and residual for July are shown in Figures 23 and 24. The actual temperature has a large overall and daily fluctuation which the prediction tracks very well. The actual measured values for this plant were given in 1 ^{o}F intervals, suggesting that the accuracy of the actual measurements are only $\underline{+}$1 ^{o}F ($\underline{+}$0.55 ^{o}C).

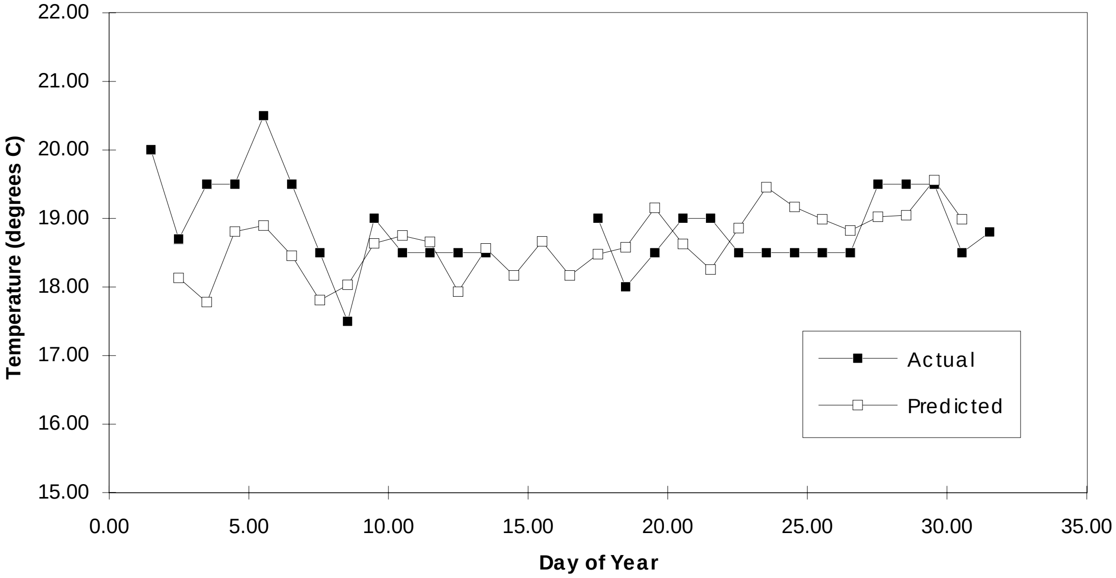

Figure 13. Chino - January Temperature Prediction

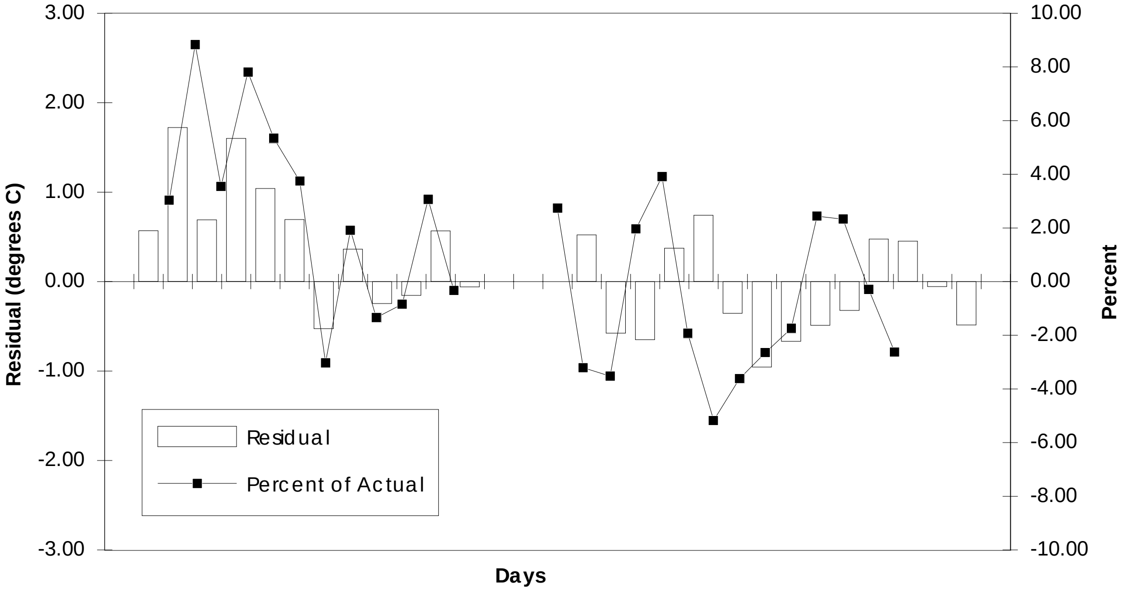

Figure 14. Chino - January Actual/Predicted Residuals

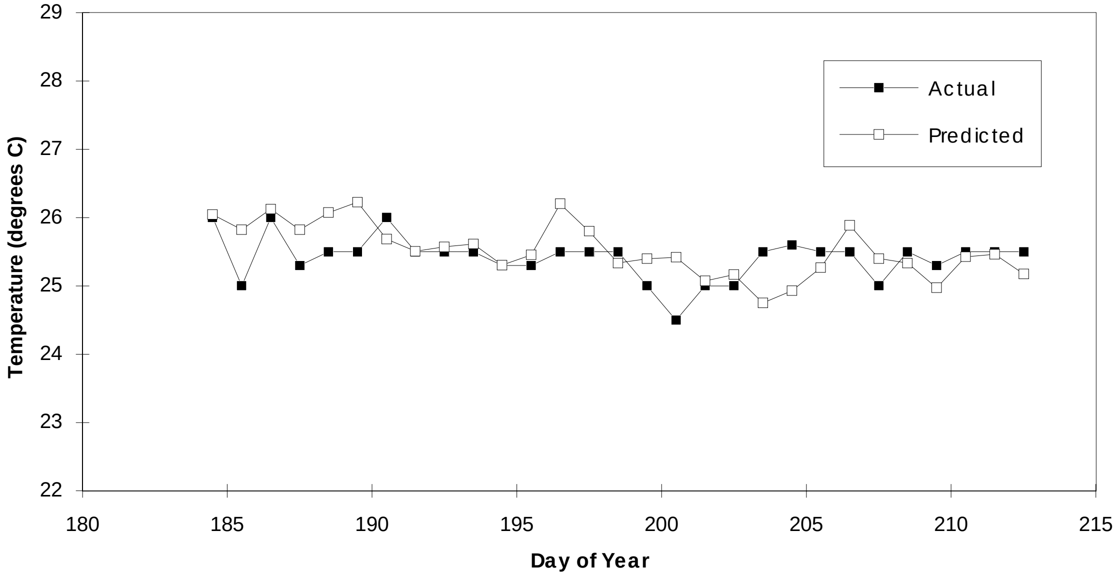

Figure 15. Chino - July Temperature Prediction

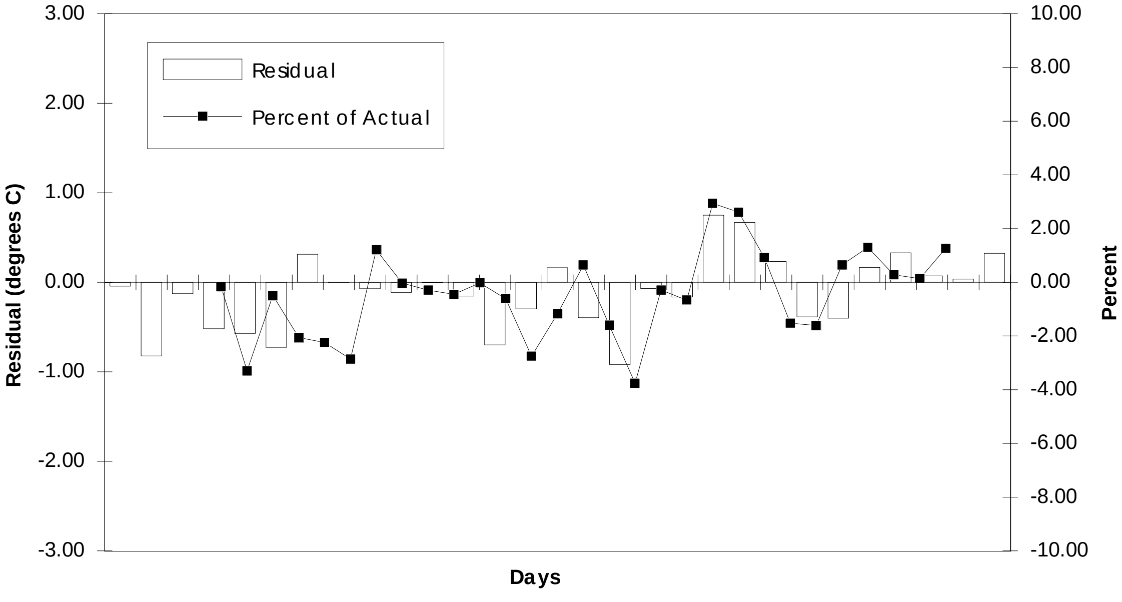

Figure 16. Chino - July Actual/Predicted Residuals

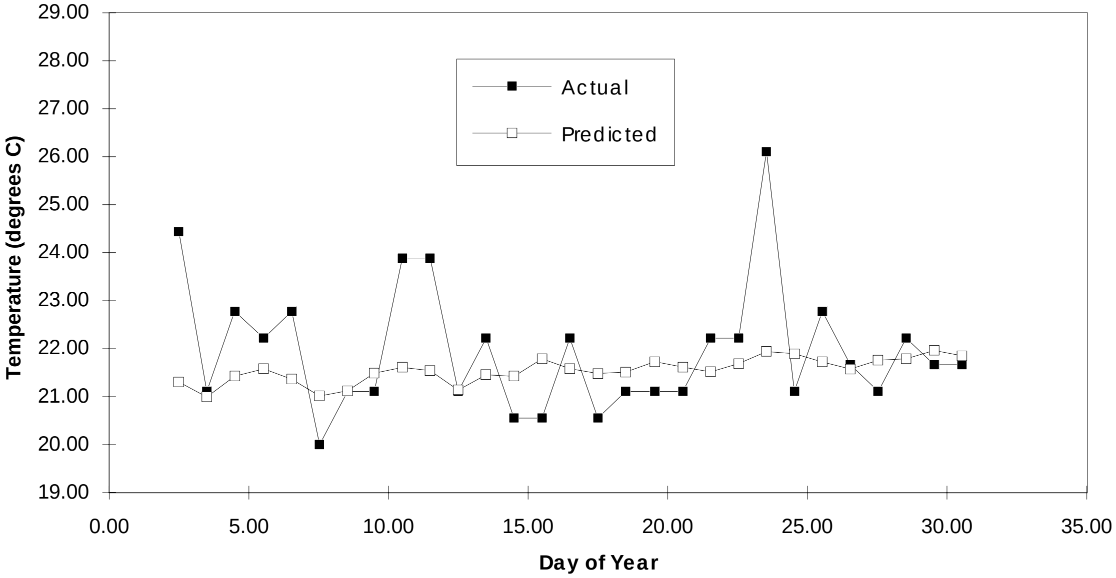

Figure 17. Terminal Island - January Temperature Prediction

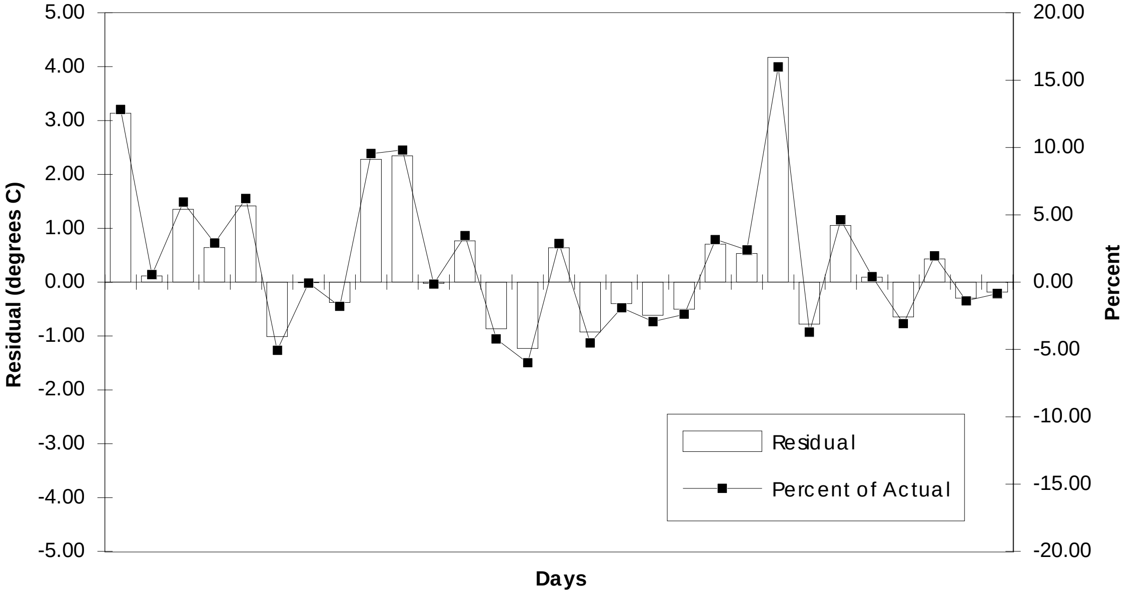

Figure 18. Terminal Island - January Actual/Predicted Residuals

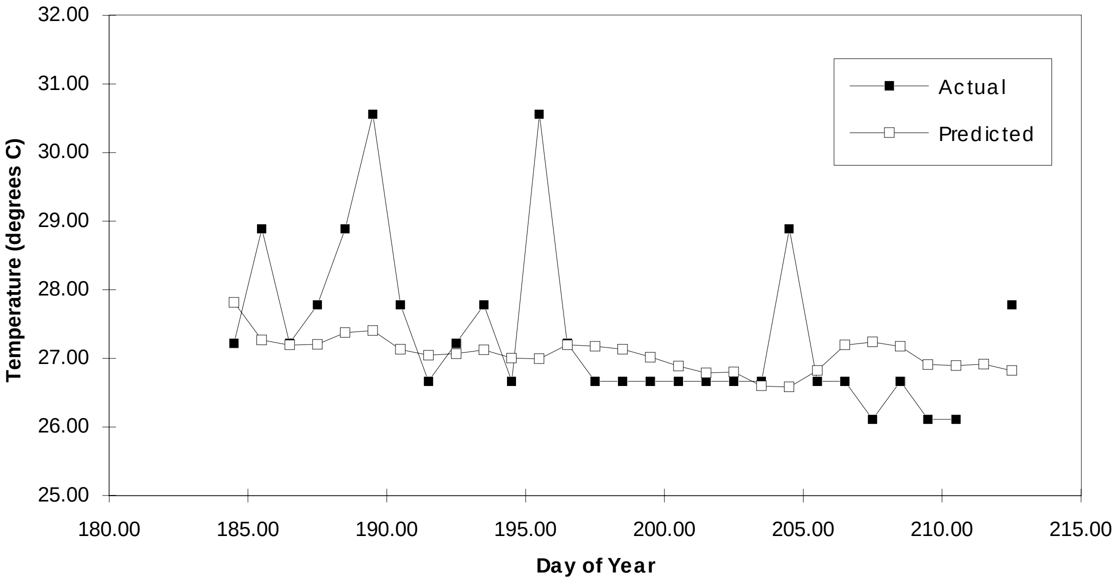

Figure 19. Terminal Island - July Temperature Prediction

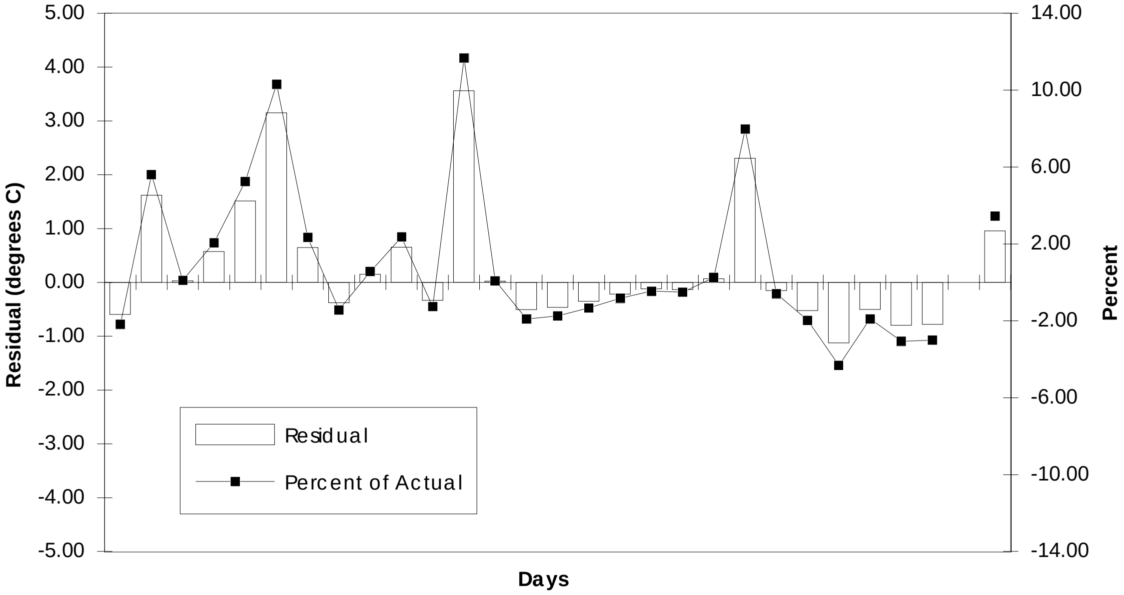

Figure 20. Terminal Island - July Actual/Predicted Residuals

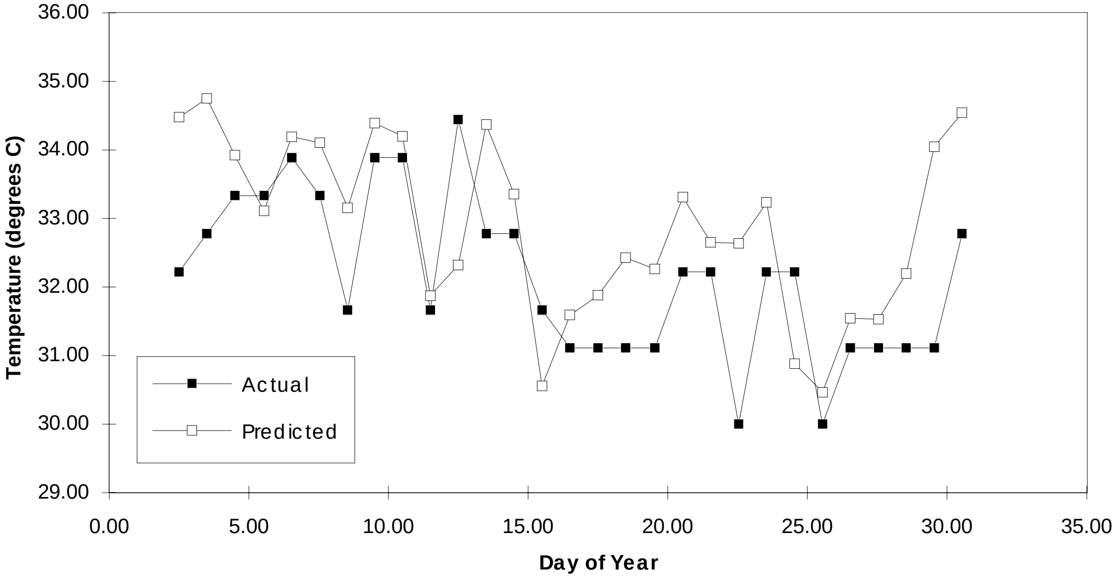

Figure 21. Pulp Mill - January Temperature Prediction

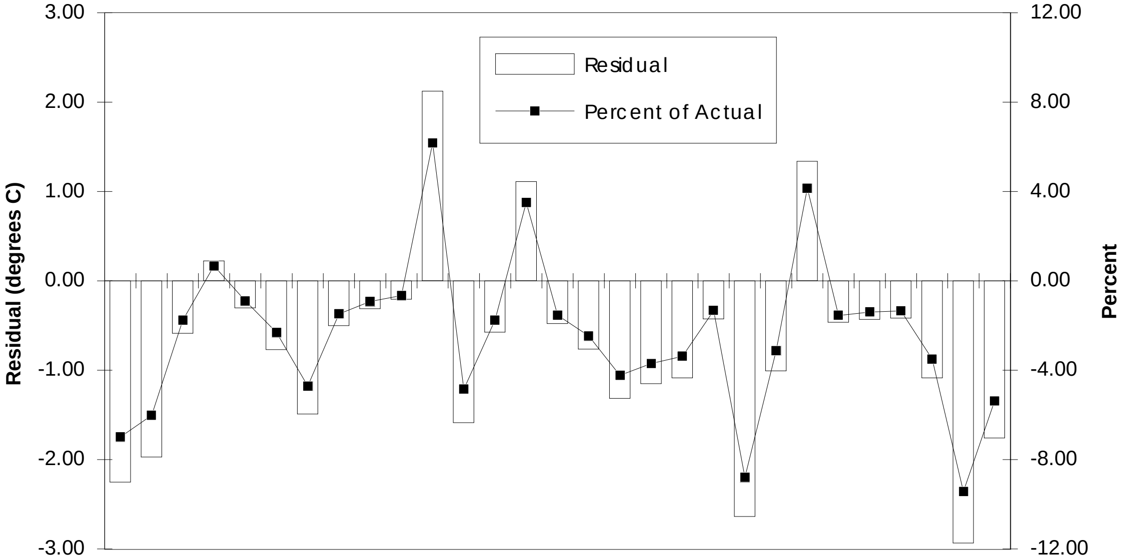

Figure 22. Pulp Mill - January Actual/Predicted Residuals

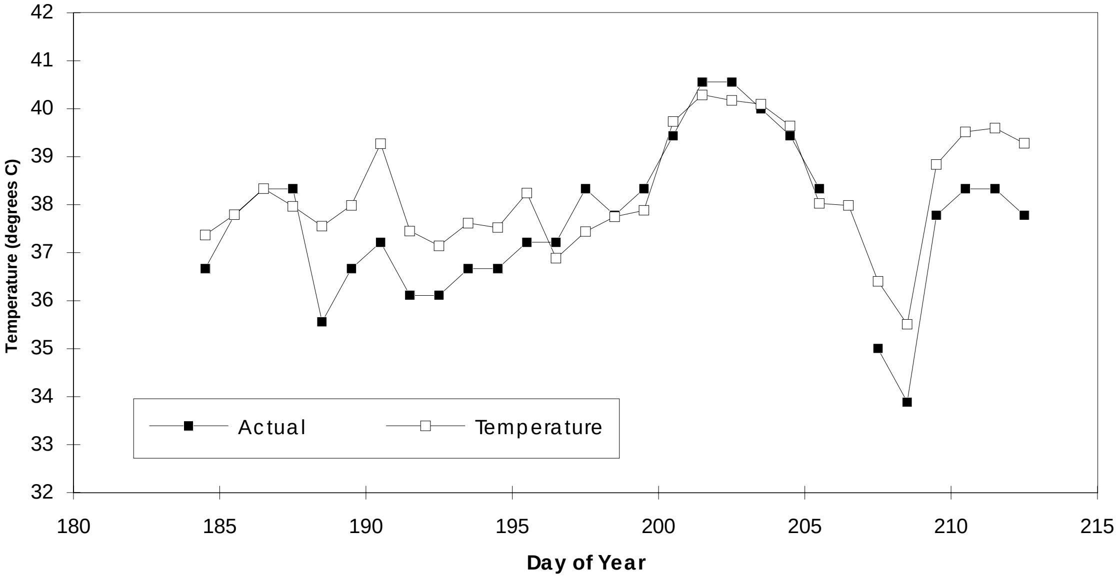

Figure 23. Pulp Mill - July Temperature Prediction

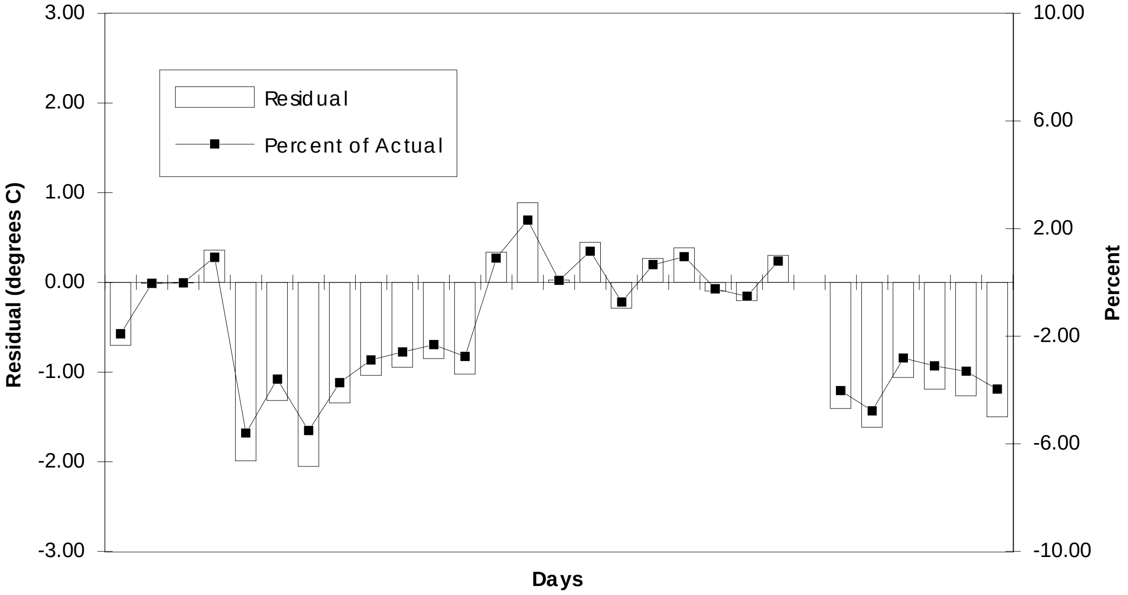

Figure 24. Pulp Mill - July Actual/Predicted Residuals

Parameter Influence and Model Sensitivity

The relative influence of the individual heat exchange components varies greatly with type of aeration, the season and all the various operating parameters. This section discusses the relative influences of each of the component heat exchanges and the sensitivity of the model to the parameters that are most significant in these influential component equations.

The proportions of each heat exchange component for all plants during January and July are depicted in Figure 25. Chino Basin, the only surface aeration plant, has the aeration heat as its major heat component. The other plants have a relatively small proportion due to aeration heat. Sacramento, Milwaukee and the pulp mill all have dramatic changes between seasons. Chino Basin and Terminal Island, both in Southern California where climatic changes are mild, are almost unchanged between seasons. This information dramatically points out the necessity of accounting for temperature in locales of changing seasonal meteorological conditions.

The sensitivity of the model to the input parameters was evaluated by selecting those heat components showing the most influence, and then determining what variables in those equations were most significant. In order to make a comparison of relative effects, a baseline temperature was determined. The July time-variant input data for the Milwaukee plant were averaged and set as constant over the month. The model was run with this new set of input data to produce a baseline temperature. Different input parameters were then changed, one at a time, to evaluate their effects. The parameters evaluated were basin area, substrate removal rate, cell yield, and all four meteorological conditions.

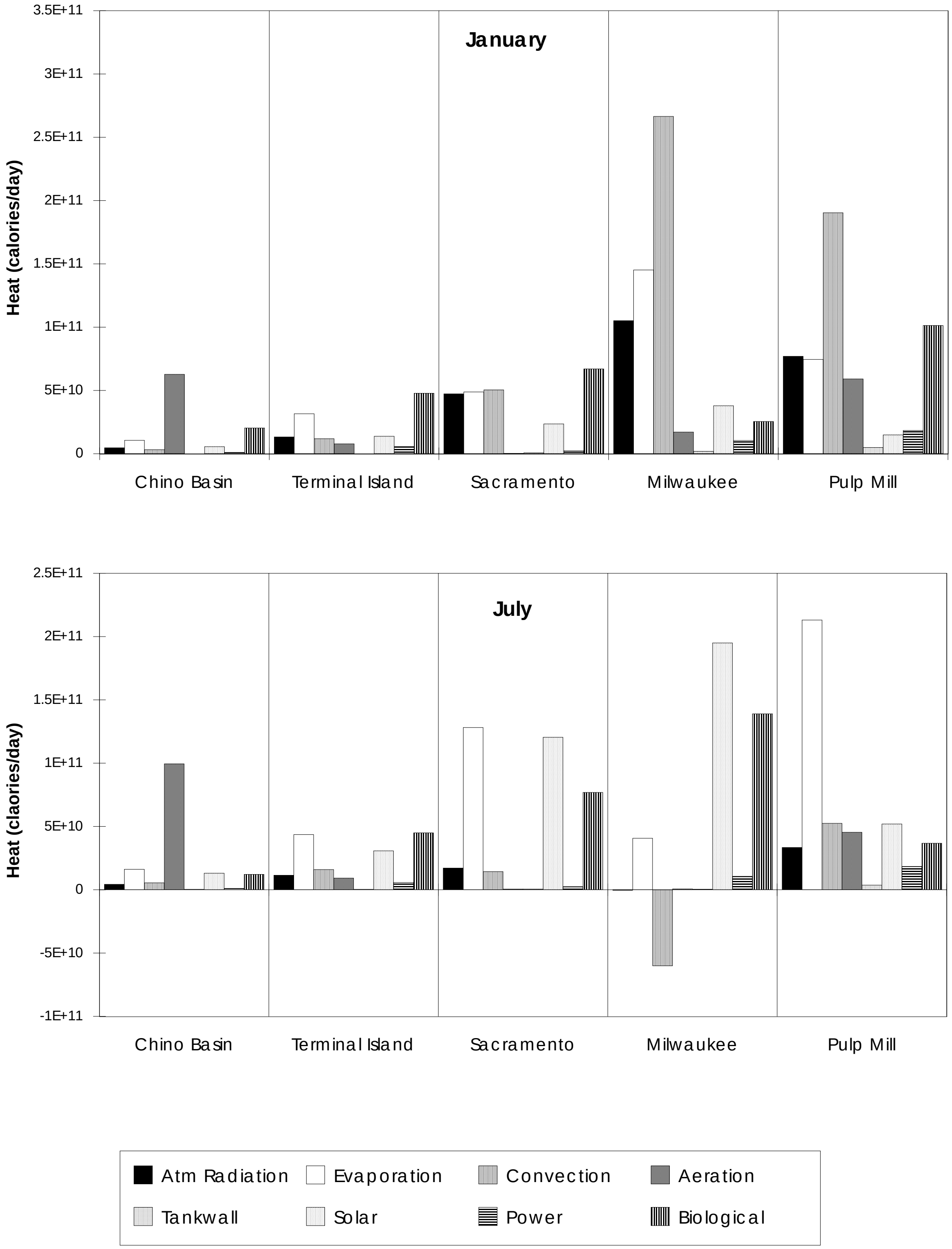

Figure 25. Proportions of Heat Exchange Component by Plant and Month

Each parameter was varied to the extremes of its range or changed by a reasonably dramatic amount: basin area at one half and twice the normal area; substrate removal rate using BOD instead of COD; cell yield at 0.5 instead of 0.23; ambient temperature at ±10°C of average; cloud cover at 0 and 10; relative humidity at 0% and 100% and windspeed at 0 and 20 m/sec. The results of these evaluations are shown in Figure 26. The ambient temperature has the most significant effect on predicted temperature. Many of the other parameters produced aeration basin temperature changes up through 0.5 °C. These results indicate that an unfortunate combination of errors can combine to become significant and care should be exercised in gathering input data.

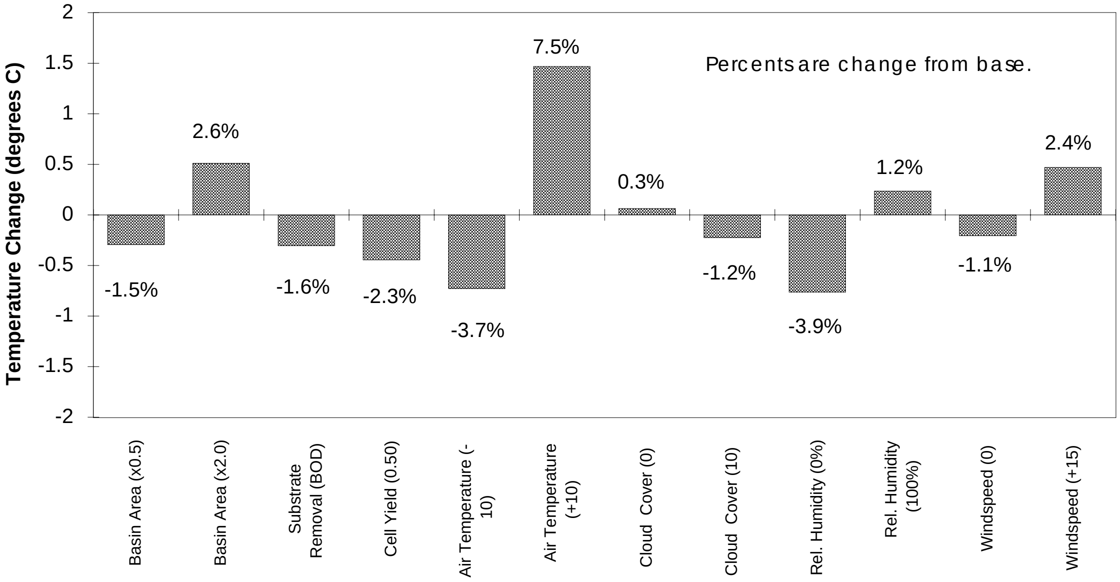

Figure 26. Model Sensitivity to Parameter Change (Milwaukee - July)

Engineering Significance

Determining wastewater aeration basin temperatures is of most importance when that information can be put to practical use. In this section the model is used to evaluate the effects of changing physical and operational parameters as well as the effects of changing meteorological conditions. This allows the investigation of controlling operational parameters to the benefit of temperature. Three scenarios were evaluated: the effects of changing surface aeration to diffused aeration and vice versa; the effects of covering an aeration basin; and the effects of ambient temperature drop due to a cold front.

Aeration Types

Conversion between surface and diffused aeration was accomplished by assuming a surface aerator oxygen transfer to horsepower efficiency of 1.8 lbs O_2/hp hr. A transfer efficiency for fine bubble diffusers was assumed for the diffused system; values of 18% and 10% were assumed for Chino Basin and Milwaukee respectively. Surface aerators have a larger capacity for evaporation than do diffused systems; therefore, surface aeration should cool a basin while diffused aeration should heat a basin.

Figures 27 and 28 show the effect of switching Chino Basin to diffused aeration. The temperature rose by approximately 1.5^{o}C in January and 2^{o}C in July. Figure 29 shows the effect of changing Milwaukee to surface aeration. In January the model predicts a decrease in temperature that dips below zero as the ambient temperature changes. Obviously the basin will not freeze, but the model does not account for the motion of the

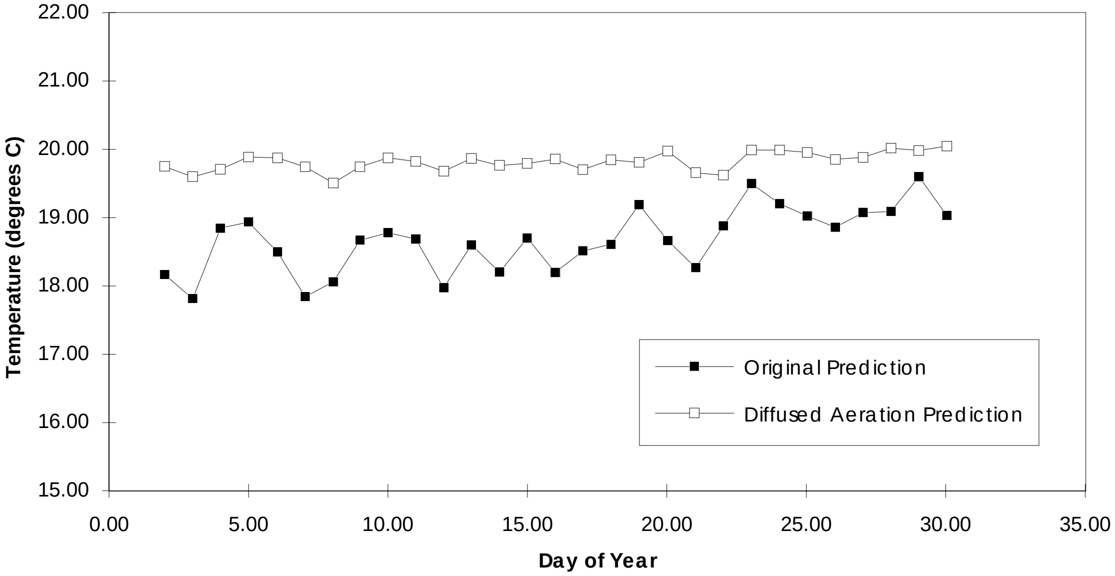

Figure 27. Chino Basin - January Diffused Aeration Prediction

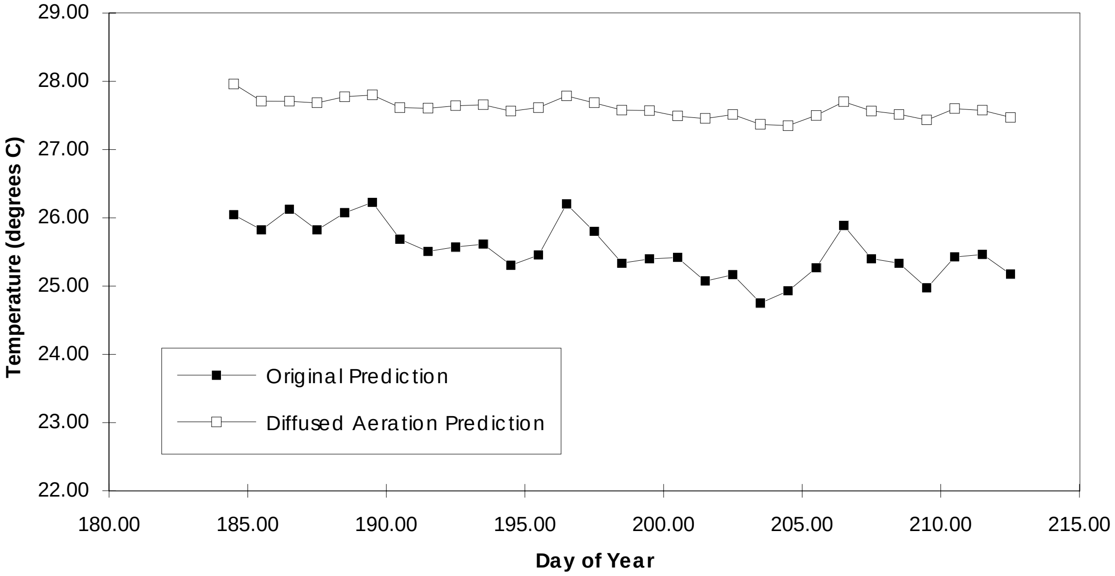

Figure 28. Chino Basin - July Diffused Aeration Prediction

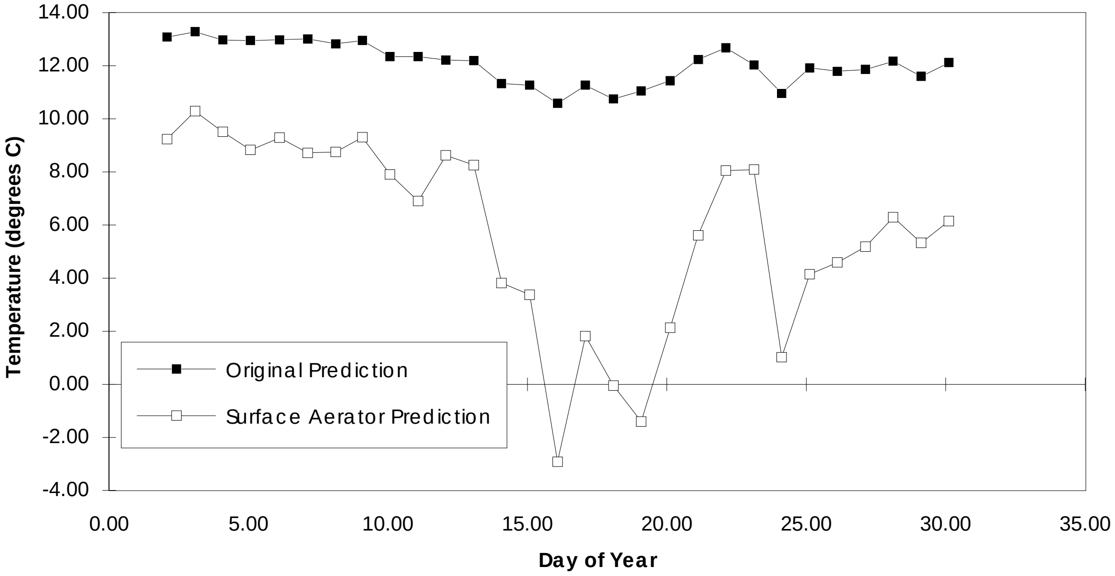

Figure 29. Milwaukee - January Surface Aeration Prediction

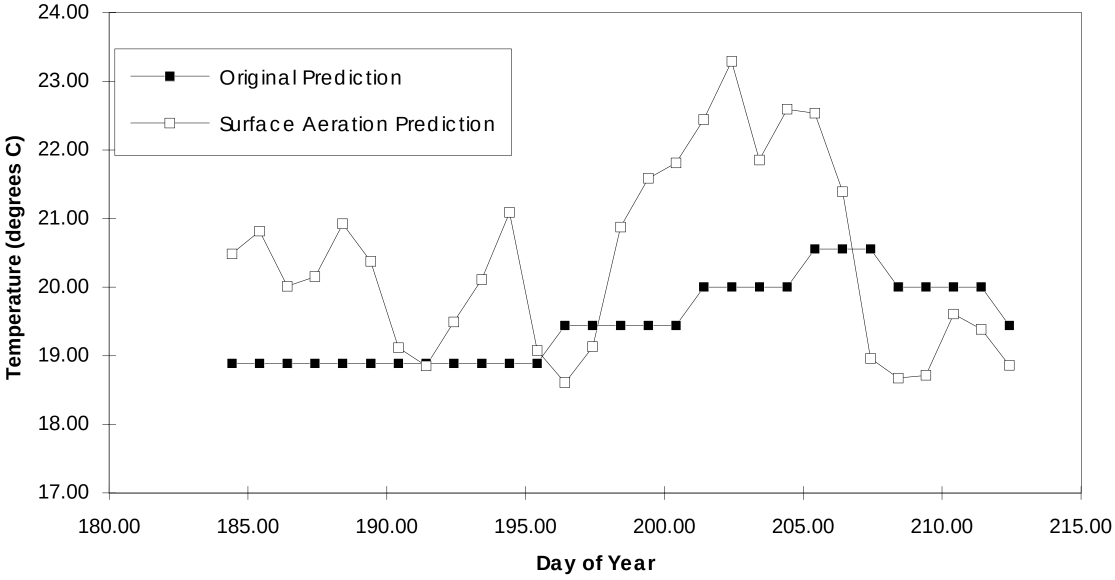

Figure 30. Milwaukee - July Surface Aeration Prediction

water or the latent heat of crystallization. However, this indicates that surface aerators under these conditions would not be practical. Interestingly, the effects in July are just the opposite. As shown in Figure 30, the temperature rises. Due to high ambient temperature there is a convective heat transfer to the aerator spray. High ambient humidity reduces the cooling effects of evaporation.

Aeration Basin Covering

To simulate the covering of aeration basins the only change necessary was to set the basin area to zero. Basin area is a multiplier in longwave radiation, solar radiation, evaporation and convection; setting basin area to zero essentially eliminates those terms from the calculation. Figure 31 shows the results based on the Milwaukee plant in July. The temperature was lowered by approximately 0.5^{o}C. The temperature difference in this case may be smaller than expected in other situations. The high ambient humidity in Milwaukee in July makes evaporation an insignifiant term which would otherwise have caused a greater effect in being eliminated.

Cold Front

Ambient temperature being an influential parameter in the model, the effects on basin temperature of a sudden change in ambient temperature may be significant. The ambient temperature for the Milwaukee plant in January showed just such a change in temperature (note the temperature drop in data Appendix C). To clearly see this effect the average temperature, temperature drop, humidity and humidity drop were determined from the data set. This information was used to set the temperature and humidity to a constant for ten days at which point the temperature was dropped 10^{o}C and the humidity 20%. The values were then returned to the previous levels after another ten days. The rate of decline and recovery of basin temperature can be observed in the results shown in Figure 32. The changes appears to take two to three days to fully manifest. This indicates that a short duration cold front may not be of concern, but longer than two to three days may cause a significant drop in basin temperature.

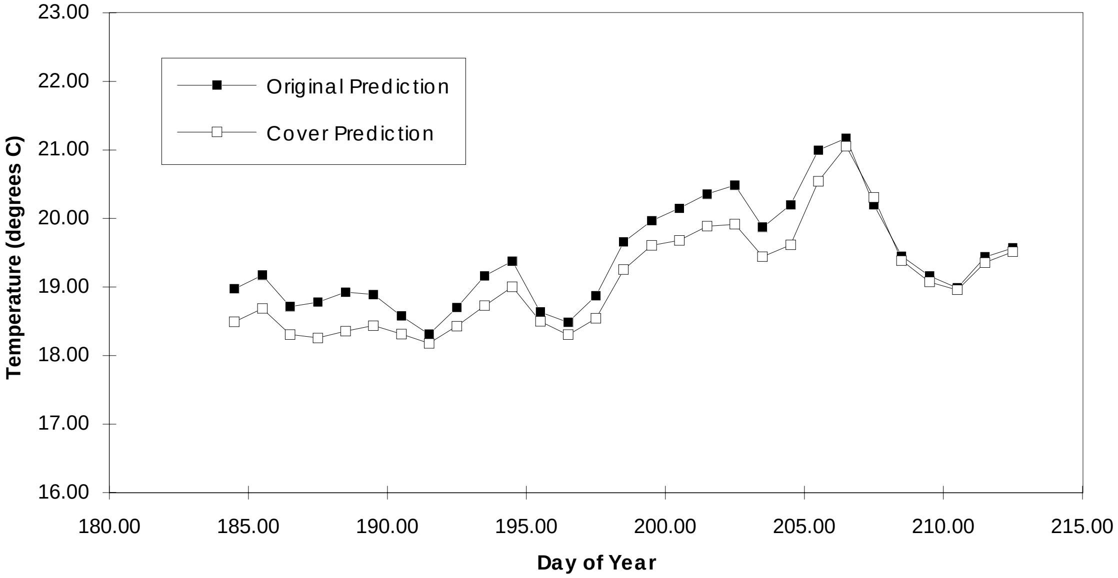

Figure 31. Effect on Basin Temperature of Covering the Aeration Basin

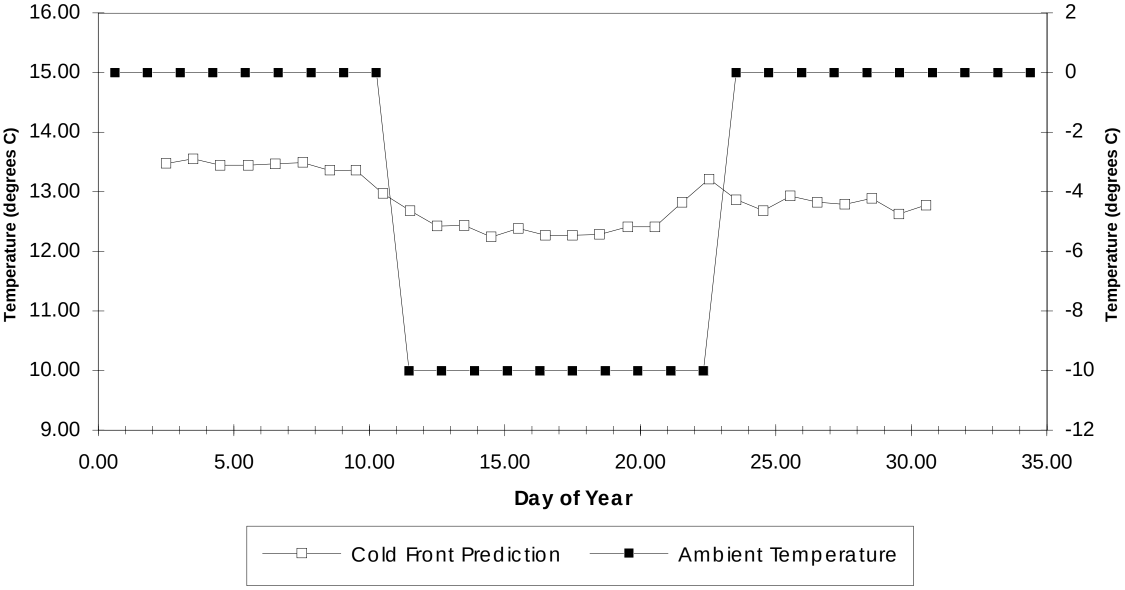

Figure 32. Effect on Basin Temperature of Cold Front

CHAPTER 5

CONCLUSIONS AND SUGGESTED FUTURE WORK

The model was successful in predicting accurate basin temperatures. The model effectively followed dips and peaks in the actual measurements. Improved calculation procedures for solar radiation input, ranges of the physical parameter regressions and biological heat calculation had an overall effect of improving model accuracy.

Several major conclusions were made from the application of this model:

- Surface aeration plants have a major portion of their heat input from the aeration term whereas this is minimal in diffused aeration plants.
- Ambient temperature is a significant factor effecting several heat components and the model output.
- A sudden change in ambient temperature, such as a cold front, takes two to three days to impact the basin temperature. Therefore, operators should be aware of the potential drop in basin temperature and plant performance under these circumstances.
- Covering aeration basins seems to have a minimal effect on basin temperature of diffused systems where the ambient humidity is high, and hence, evaporation is low.
- Accuacy of temperature predictions was $\pm0.5^{o}$C for Milwaukee, Chino Basin and Terminal Island and $\pm1.0^{o}$C for Sacramento and the pulp mill.

Plants expecting to upgrade or expand their facilities should perform a temperature analysis to determine if process design options can materially impact plant aeration basin temperature and plant performance. To perform such an analysis the input data required for this model, as described in Chapter 3 - Model Results, should be collected frequently and accurately. Several of these parameters are not usually collected accurately or at all: influent and effluent temperature of the aeration basin, COD in and out of basin, VSS of the mixed liquor for accurate cell yield determination, compressor/aerator motor efficiency and meteorological conditions at plant.

The most significant area for improvement is in the further evaluation of the models accuracy. Complete data sets with greater frequency and accuracy were not obtainable from the plants queried. A project to collect this data accurately and on a more frequent basis will probably be necessary to obtain a thorough set of input data. This data could be used to evaluate how accurate the model is. This, in turn, would show which heat transfer terms may require further revisions.

Functional improvements in the data entry spreadsheet system are always possible. Undoubtedly others using the program will have suggestions as to user-friendly operational improvements.

CHAPTER 6

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APPENDIX A

NOMENCLATURE

alt = solar altitude (degrees)

A_w = area exposed to air (m^2)

A_w = area exposed to ground (m^2)

CC = cloud cover (0-10)

c_{hp} = conversion factor for horsepower to calories (cal./hp)

c_{pa} = specific heat of air (cal/kg ^{o}C)

c_{pw} = specific heat of water (cal/kg ^{o}C)

F = aerator spray area (m2)

ΔH = enthalpy change between influent and effluent streams (cal/day)

h_f = exit air humidity factor

h_v = vapor phase transfer coefficient

k_1, k_2 = thermal conductivity of materials (BTU/hr ft^2 ^{o}F inch)

K_i = surface conductance at the air-surface area inside tank (BTU/hr ft^2 ^{o}F)

K_o = surface conductance at the air-surface area outside tank (BTU/hr ft^2 ^{o}F)

L = latent heat of vaporization (cal/kg)

M_w = molecular weight of water

N = number of aerators

P = WIRE horsepower

Q_a = aeration heat

q_a = air flow rate (m^3/sec)

Q_{al} = latent heat exchange

Q_{as} = sensible heat exchange

Q_b = biological reaction heat

Q_c = surface convection heat

Q_e = surface evaporation heat

Q_{lr} = long wave (atmospheric) radiation heat

Q_p = mechanical power heat

Q_{so} = clear sky solar radiation (cal/day)

Q_{sr} = solar radiation heat

Q_t = net heat gain or loss (cal/day)

Q_{tw} = tank wall heat

q_w = volumetric flow rate (m^3/day)

R = universal gas constant (62.361 mm Hg-l/gmole oK4)

r_h = relative humidity (%)

ΔS = substrate removal rate (g of COD/day)

T_a = ambient air temperature (^{o}C)

T_g = temperature of the ground (^{o}C)

T_i = temperature of influent stream (^{o}C)

T_w = temperature of basin water (^{o}C)

U_a = overall heat transfer coefficient for conduction to air (cal/day m^2 ^{o}C)

U_g = overall heat transfer coefficient for conduction to ground (cal/day m^2 ^{o}C)

V = volume of basin (m^3)

v_a = vapor pressure of water at air temperature (cal/kg)

v_w = vapor pressure of water at basin temperature (cal/kg)

W = wind velocity at water surface (m/sec)

x_1,x_2 = thickness of materials (inches)

y = cell yield (g of VSS/g of COD)

β = atmospheric radiation factor

ε = emissivity of the water surface (0.97)

η = efficiency (%)

λ = reflectivity of water surface (0.03)

ρ_a = density of air (kg/m^3)

ρ_w = density of water (kg/m^3)

σ = Stefan Boltzman constant [1.17x10^{-3} cal/(m^2 day K^4)]

APPENDIX B

SOLAR EQUATIONS

The determination of solar radiation input is derived from several celestial parameters. As presented in Chapter 2 - Solar Radiation, the clear sky solar radiation is a function of the solar altitude. Solar altitude is the complement to the zenith angle (sin *alt* = cos *Z*), which is determined from the celestial alignment of the earth and the sun, and the exact location on the earth's surface. The zenith angle is not normally measured directly, but can be defined in terms of other known angles.

$$\cos Z = \sin\varphi\sin\delta + \cos\varphi\cos\delta\cos h \qquad \text{(B-1)}$$

where

Z = zenith angle

φ = latitude

δ = solar declination

h = hour angle

These terms must be defined by algebraic equations in order to be represented by a mathematical model. The hour angle is defined as the angle between the observers zenith or local celestial meridian and the meridian of the sun. The hour angle is zero at solar noon, and increases by 15^{o} for every hour before or after solar noon. Hour angle is represented by equation (B-2).

$$h = -180 + 15\ (t - \text{long.}) \qquad \text{(B-2)}$$

where

t = time of day (GMST)

long = longitude

Solar declination is defined in terms of two other celestial parameters, which are in turn ultimately defined by the date and time. Solar declination and the other terms are listed as equations (B-3) to (B-8). (The Astronomical Almanac 1992).

Solar declination:

$$\delta = \sin^{-1}(\sin \varepsilon \sin \lambda) \qquad \text{(B-3)}$$

Obliquity of ecliptic:

$$\varepsilon = 23^{\circ}.439 - 0^{\circ}.0000004\, n \qquad \text{(B-4)}$$

Ecliptic longitude:

$$\lambda = L + 1^{\circ}.915 \sin g + 0^{\circ}.020 \sin 2g \qquad \text{(B-5)}$$

Mean longitude of Sun, corrected for aberration:

$$L = 280^{\circ}.460 + 0^{\circ}.9856474\, n \qquad \text{(B-6)}$$

Mean anomaly:

$$g = 357^{\circ}.528 + 0^{\circ}.9856003\, n \qquad \text{(B-7)}$$

Time argument:

$$n = -2923.5 + \text{day of year} + \text{fraction of day from } 0^{h}\ \text{UT} \qquad \text{(B-8)}$$

The day of the year is a value from 1 to 365, the fraction of day from 0^{h} UT (universal time) is the local time converted to UT (same as GMST here) and divided by 24 hours. The variables L and g are put in the 0° to 360° range by adding multiples of

360^o. Equations (B-4) to (B-8) are sequentially substituted to arrive at equation (B-3). Finally, equation (B-3) and (B-2) can be substituted into (B-1) along with the latitude of the location. Equation (B-1), the cosine of the zenith angle is equivalent to the sin of the solar altitude. Taking the arcsin of equation (B-1) will produce the solar altitude, which can be used in equation (3) in Chapter 2 - Solar Radiation for determining clear sky solar radiation on the earths surface.

APPENDIX C

FORTRAN PROGRAMS

```
************************************************************************
*            Dynamic Model for the Prediction of Temperature           *
*                     in a Wastewater Aeration Basin                   *
*                                 By                                   *
*                            Paul Sedory                               *
*                                                                      *
************************************************************************




C.. MAIN PROGRAM
      real atemp(100,2),wind(100,2),humid(100,2),cloud
     1(100,2),infflow(100,2),inftemp(100,2),airflo(100,2),numaer(100,2)
     2,sprarea(100,2),sbremrt(100,2),solrad(100,2),lat,long
C.. HEADINGS FOR TEMPERATURE OUTPUT FILE AND HEAT TERM OUTPUT FILE.
      open (9,file='final.dat')
      write(9,2000)
2000  format (1x,'Time',2x,'Temperature')
      open (10,file='heats.dat')
      write (10,2001)
2001  format (2x,'time',6x,'hlwsr',7x,'hevap',7x,'hconv',7x,'haer',8x,
     1'htnkwal',5x,'hswsr',7x,'hpwr',8x,'hbiorxn',5x,'sumofh')
C.. READS IN CONSTANTS FILE
      open (8,file='constant.dat')
      read (8,1000) lat,long,tgrd,barea,volume,areaair,htcoair,areagrd,
     1htcogrd,powers,effs,powerd,effd,cellyld,sdate,duration,printerv,
     2stwinit
1000  format (3(f8.0,/),/,11(f8.0,/),/,3(f8.0,/),f8.0)
      close (8)
C.. OPEN AND OUTPUT FILE AND WRITE INPUT DATA
      open (7,file='output.dat')
      write (7,1001) lat,long, tgrd,
     1barea,volume, areaair, htcoair, areagrd, htcogrd, powers, effs,
     2powerd,effd, cellyld, sdate, duration, printerv,stwinit
1001  format ('Latitude= ',f6.2/,'Longitude= ',f6.2/,'Ground
     1Temperature= ',f5.2/,'Basin Surface Area= ',f8.0/,'Basin Volume= '
     2,f8.0/,'Submerged Wall Area Exposed to Air= ',f8.0/,
     4'Heat Transfer Coefiicient to Air= ',f7.0/,'Submerged Wall Area'
     5' Exposed to Ground= ',f8.0/,'Heat Transfer Coefficient'
     6' to Ground= ',f7.0/,'Power Input to Aerator= ',f7.1/,'Efficiency'
     7' of Aerator= ',f4.0/,'Power Input to Compressor= ',f7.1/,
     8'Efficiency of Compressor= ',f4.0/,'Cell Yield= ',f4.2/,
     9'Start Date= ',f8.4/,'Model Duration= ',f8.4/,'Print Time'
     1' Interval= ',f8.4/,'Initial Basin Temperature Estimate= ',f5.2)
C.. AIR TEMPERATURE ARRAY
      open (8, file='airtemp.dat')
      do 10, I=1,100
       read (8, 1010, end=20) atemp(I,1), atemp(I,2)
10    iatemp=I
1010  format (f8.0,2x,f12.0)
20    write (7,1011) (atemp(I,1), atemp(I,2), I=1,Iatemp)
1011  format (1x, 'Air temperature data'/1x,'DateTime',1x,'Temperature'
     1,/,100(f8.4,2x,f8.2,/))
C.. WIND SPEED ARRAY
      open (8, file='windspd.dat')
```

```
      do 30, I=1,100
       read (8, 1010, end=40) wind(I,1), wind(I,2)
30    Iwind=I
40    write (7,1020) (wind(I,1), wind(I,2), I=1,iwind)
1020  format (1x, 'Wind Speed data'/1x,'DateTime',1x,'Wind Speed'
     1,/,100(f8.4,2x,f8.1,/))
C.. RELATIVE HUMIDITY ARRAY
      open (8, file='rhumid.dat')
      do 50, I=1,100
       read (8, 1010, end=60) humid(I,1), humid(I,2)
50    Ihumid=I
60    write (7,1030) (humid(I,1), humid(I,2), I=1,ihumid)
1030  format (1x, 'Relative Humidity data'/1x,'DateTime',1x,'Humidity'
     1,/,100(f8.4,2x,f8.0,/))
C.. CLOUD COVER ARRAY
      open (8, file='clouds.dat')
      do 70, I=1,100
       read (8, 1010, end=80) cloud(I,1), cloud(I,2)
70    Icloud=I
80    write (7,1040) (cloud(I,1), cloud(I,2), I=1,icloud)
1040  format (1x, 'Cloud Cover data'/1x,'DateTime',1x,'Cloud Cover'
     1,/,100(f8.4,2x,f8.1,/))
C.. INFLUENT FLOW ARRAY
      open (8, file='wwflow.dat')
      do 90, I=1,100
       read (8, 1010, end=100) infflow(I,1), infflow(I,2)
90    Iinfflo=I
100   write (7,1050) (infflow(I,1), infflow(I,2), I=1,iinfflo)
1050  format (1x, 'Influent Flowrate data'/1x,'DateTime',1x,'Influent
     1Flowrate',/,100(f8.4,2x,f8.0,/))
C.. INFLUENT TEMPERATURE ARRAY
      open (8, file='intemp.dat')
      do 110, I=1,100
       read (8, 1010, end=120) inftemp(I,1), inftemp(I,2)
110   Iinftemp=I
120   write (7,1060) (inftemp(I,1), inftemp(I,2), I=1,iinftemp)
1060  format (1x, 'Influent Temperature data'/1x,'DateTime',1x,
     1'Influent Temperature',/,100(f8.4,2x,f8.1,/))
C.. DIFFUSED AIR FLOWRATE ARRAY
      open (8, file='airflow.dat')
      do 130, I=1,100
       read (8, 1010, end=140) airflo(I,1), airflo(I,2)
130   iairflo=i
140   write (7,1070) (airflo(I,1), airflo(I,2), I=1,iairflo)
1070  format (1x, 'Diffused Air Flowrate data'/1x,'DateTime',1x,
     1'Air Flowrate',/,100(f8.4,2x,f8.0,/))
C.. NUMBER OF AERATORS ARRAY
      open (8, file='numbaer.dat')
      do 150, I=1,100
       read (8, 1010, end=160) numaer(I,1), numaer(I,2)
150   Inumaer=I
160   write (7,1080) (numaer(I,1), numaer(I,2), I=1,inumaer)
1080  format (1x, 'Number of Aerators data'/1x,'DateTime',1x,
     1'Number of Aerators',/,100(f8.4,2x,f8.1,/))
C.. AERATOR SPRAY AREA ARRAY
      open (8, file='aerarea.dat')
      do 170, I=1,100
       read (8, 1010, end=180) sprarea(I,1), sprarea(I,2)
170   Isprarea=I
180   write (7,1090) (sprarea(I,1), sprarea(I,2), I=1,isprarea)
```

```
1090  format (1x, 'Spray Area data'/1x,'DateTime',1x,'Spray Area'
     1,/,100(f8.4,2x,f8.1,/))
C.. SOLAR RADIATION ARRAY
      open (8, file='solarad.dat')
      do 190, I=1,100
       read (8, 1010, end=200) solrad(I,1), solrad(I,2)
190   Isolrad=I
200   write (7,1100) (solrad(I,1), solrad(I,2), I=1,isolrad)
1100  format (1x, 'Solar Radiation Data'/1x,'DateTime',1x,
     1'Solar Radiation',/,100(f8.4,2x,f8.0,/))
C.. SUBSTRATE REMOVAL RATE ARRAY
      open (8, file='subremrt.dat')
      do 210, I=1,100
       read (8, 1010, end=220) sbremrt(I,1), sbremrt(I,2)
210   Isbremrt=I
      close (8)
220   write (7,1110) (sbremrt(I,1), sbremrt(I,2), I=1,isbremrt)
1110  format (1x, 'Substrate Removal Rate data'/1x,'DateTime',1x,
     1'Substrate Removal Rate',/,100(f8.4,2x,f8.0,/))
C.. CALLS SUBROUTINE TO DETERMINE EQUILIBRIUM TEMPERATURE TO USE AS
C   INITIAL TEMPERATURE FOR DYNAMIC MODELING.
      time=sdate
      call init(lat,long,atemp(1,2),wind(1,2),humid(1,2),
     1cloud(1,2),powerd,effd,powers,effs,htcoair,htcogrd,
     2cellyld,infflow(1,2),inftemp(1,2),airflo(1,2),numaer(1,2),
     3sprarea(1,2),sbremrt(1,2),stwinit,barea,time
     4,areaair,areagrd,tgrd,twinit,solrad(1,2))
C.. PARAMETER INITIALIZATION
      timestep=0.0416667
      ptime=sdate
C.. CALL SUBROUTINE TO CALCULATE DTWDT AND THEN PERFORM 2ND ORDER
NUMERICAL
C    INTEGRATION
250   continue
      call sumh(lat,long,atemp,wind,humid,cloud,powerd,effd,
     1powers,effs,htcoair,htcogrd,cellyld,infflow,inftemp,
     2airflo,numaer,sprarea,sbremrt,twinit,barea,volume,time,dTwdt,
     3areaair,areagrd,tgrd,iatemp,iwind,ihumid,icloud,iinfflo,
     4inumaer,isprarea,isbremrt,iinftemp,iairflo,beta,solrad,isolrad,
     5hlwsr,hevap,hconv,haer,htnkwal,hswsr,hpwr,hbiorxn,sumofh)
      Thalf=Twinit+timestep/2.*dTwdt
      TwinitA=Twinit
      Twinit=Thalf
      call sumh(lat,long,atemp,wind,humid,cloud,powerd,effd,
     1powers,effs,htcoair,htcogrd,cellyld,infflow,inftemp,
     2airflo,numaer,sprarea,sbremrt,twinit,barea,volume,time,dTwdt,
     3areaair,areagrd,tgrd,iatemp,iwind,ihumid,icloud,iinfflo,
     4inumaer,isprarea,isbremrt,iinftemp,iairflo,beta,solrad,isolrad,
     5hlwsr,hevap,hconv,haer,htnkwal,hswsr,hpwr,hbiorxn,sumofh)
      Tfull=TwinitA+timestep*dTwdt
      Twinit=Tfull
C.. CHECK TO SEE IF TEMPERATURE SHOULD BE PRINTED AND CHECK MODEL
DURATION
C    TO DETERMINE CONTINUATION OF PROGRAM
      if (time.ge.ptime) then
        write(9,2010) time,tfull
2010    format (1x,f6.2,2x,f6.3)
        write (10,2050) time,hlwsr,hevap,hconv,haer,
     1  htnkwal,hswsr,hpwr,hbiorxn,sumofh
2050    format (f8.4,2x,9(e10.4,2x))
```

```
        ptime=ptime+printerv
      endif
      time=time+timestep
      if (time.lt.(sdate+duration))then
        goto 250
      endif
      Write (*,*) 'This program has successfully completed'
      end







***********************************************************************
* Subroutine INIT calculates the equilibrium tmeperature to use as the*
*   initial temperature for the dynamic portion.  This temperature is *
*   determined by the iterative static method with static inputs.     *
***********************************************************************

      Subroutine init(lat,long,tamb,windspd,rhumid,clouds,powerd
     1,effd,powers,effs,htcoair,htcogrd,cellyld,wwflow,intemp,
     2airflow,numbaer,aerarea,subremrt,stwinit,barea,time,
     3areaair,areagrd,tgrd,twinit,solrad)
      real intemp,numbaer,lat,long,ntwinit
100   continue
C.. POLYNONMIAL EQUATIONS FOR PHYSICAL CONSTANTS
      airdens=(0.001293/(1+0.00367*tamb))*1000
      wtrdens=999.856+0.058088*stwinit-7.81419e-3*stwinit**2+3.98694e-5*
     1stwinit**3
      sphtair=(0.246004+5.8129e-5*tamb+2.44014e-6*tamb**2-7.85452e-8*
     1tamb**3+8.53318e-10*tamb**4-3.15067e-12*tamb**5)*1000
      sphtwtr=(1.00721-8.1362e-4*stwinit+2.68624e-5*stwinit**2-4.28432
     1e-7*stwinit**3+3.50166e-9*stwinit**4-1.09329e-11*stwinit**5)*1000
      LHV=(595.66886002-0.53228271618*stwinit+8.6706135756e-05*
     1stwinit**2)*1000
      Vapair=4.6667+0.33498*tamb+0.0097951*tamb**2+2.0664e-04*tamb**3
     1+3.3009E-06*tamb**4
      Vapbasin=4.6667+0.33498*twinit+0.0097951*twinit**2+2.0664e-04*
     1twinit**3+3.3009E-06*twinit**4
      reflwtr=0.03
      emiswtr=.97
C.. NET HEAT GAIN FROM SHORT WAVE SOLAR RADIATION
      if (solrad.eq.0)then
        call solar (time,lat,long,hswsr0)
       else
        hswsr0=solrad
      endif
      hswsr=hswsr0*(1-0.0071*clouds**2)*barea
C.. ENERGY EXCHANGE FROM LONGWAVE (INFRARED) SOLAR RADIATION.
      a=0.7399300762+0.010352672786*clouds-1.9812639499e-05*clouds**2
      b=(0.14729812741-5.6951848819e-05*clouds**3)/10
      beta=a+b*vapair*0.5357756
      hlwsr = (emiswtr * 1.17e-3 * (stwinit + 273)**4 * barea)
     1- ((1 - reflwtr) * beta * 1.17e-3 * (tamb + 273)**4 *
     2barea)
C.. ENERGY EXCHANGE FROM EVAPORATION AT BASIN SURFACE.
      hevap = (1.145e6 * (1 - rhumid/100) + 6.86e4 * (stwinit -
     1tamb)) * exp (0.0604 * tamb) * windspd * barea **0.95
C.. ENERGY EXCHANGE FROM CONVECTION AT BASIN SURFACE.
```

```
      hconv = airdens * sphtair * 392 * barea**(0.95) *
     1windspd * (stwinit - tamb)
C.. ENERGY EXCHANGE FROM AERATION.
C.. LATENT PORTION
      humifact=1.0
      gasflowu=numbaer*aerarea*windspd
      hlatentu = (18 * gasflowu * lhv)/(100 * 62.361) * 86400 *
     1((vapbasin * (rhumid + humifact * (100 - rhumid))
     2/(twinit + 273)) - (vapair * rhumid)/(tamb + 273))
      gasflowd=airflow
      hlatentd = (18 * gasflowd * lhv)/(100 * 62.361) * 86400 *
     1((vapbasin * (rhumid + (100 - rhumid))
     2/(twinit + 273)) - (vapair * rhumid)/(tamb + 273))
      hlatent=hlatentu+hlatentd
C.. SENSIBLE PORTION
      if(numbaer.eq.0..or.aerarea.eq.0.)then
        hsensblu=0
      else
        hsensblu = (392 * numbaer*aerarea **(-0.05) * windspd) * barea *
     1  airdens * sphtair * (twinit - tamb)
      endif
      hsensbld = airflow * airdens * sphtair * 86400 *
     1(twinit - tamb)
      hsensbl=hsensblu+hsensbld
      haer = hlatent + hsensbl
C.. ENERGY EXCHANGE FROM TANK WALL, BOTH ABOVE AND BELOW
C   GROUND EXPOSURE.
      htwair = htcoair * areaair * (stwinit - tamb)
      htwgrd = htcogrd * (areagrd+barea) * (stwinit - tgrd)
      htnkwal = htwair + htwgrd
C.. ENERGY EXCHANGE FROM POWER INPUT (SURFACE AERATOR OR DIFFUSED AIR)
      hpwrd = 15398784 * powerd* (1 - effd/100)
      hpwrs = 15398784 * powers* (effs/100)
      hpwr=hpwrs+hpwrd
C.. ENERGY EXCHANGE FROM BIOLOGICAL REACTION.
      hbiorxn = (3.3 - 5.865 * cellyld) * 1e06 * subremrt
C.. SUM OF ENERGY EXCHANGE TERMS
      sumofh = -hlwsr - hevap - hconv - haer - htnkwal +
     1hswsr + hpwr + hbiorxn
C.. OVERALL ENERGY BALANCE EQUATION SOLVED IMPLICITLY FOR BASIN
TEMPERATURE.
      ntwinit=intemp+(sumofh/(wtrdens * sphtwtr * wwflow))
C.. ITERATIVE SUBSTITUTION TO SOLVE ABOVE EQUATION
      diff=abs(stwinit-ntwinit)
      if (diff.gt.0.10.and.diff.lt.100) then
        stwinit=0.97*stwinit+0.03*ntwinit
        goto 100
       elseif (diff.ge.100) then
        write (*,*) 'The initial estimate for basin temperature is ',
     1                'too far off, the program cannot converge.'
        stop
      endif
      twinit=ntwinit
      return
      end
```

```
***********************************************************************
* Subroutine SUMH calculates the slope of the temperature gradient,*
* in order to do this it first calculates the overall energy exchange *
*   by calculating the individual energy terms and summing them.      *
***********************************************************************

      Subroutine sumh(lat,long,atemp,wind,humid,cloud,powerd,
     1effd,powers,effs,htcoair,htcogrd,cellyld,infflow,inftemp,
     2airflo,numaer,sprarea,sbremrt,twinit,barea,volume,time,dTwdt,
     3areaair,areagrd,tgrd,iatemp,iwind,ihumid,icloud,iinfflo,
     4inumaer,isprarea,isbremrt,iinftemp,iairflo,beta,solrad,isolrad,
     5hlwsr,hevap,hconv,haer,htnkwal,hswsr,hpwr,hbiorxn,sumofh)
      real atemp(100,2),wind(100,2),humid(100,2),cloud(100,2),infflow
     1(100,2),inftemp(100,2),airflo(100,2),numaer(100,2),sprarea(100,2)
     2,sbremrt(100,2),solrad(100,2),lat,long,intemp,numbaer
C.. ARRAYS NEEDED FOR ERROR CHECKING IN AFGEN FUNCTION.
      integer aair(5), awin(5), arhu(5), aclo(5), awwf(5),
     1aint(5), aairf(5), anum(5), aaer(5), asubr(5),asol(5)
      data aair/5*0/,awin/5*0/,arhu/5*0/,aclo/5*0/,awwf/5*0/,
     1aint/5*0/,aairf/5*0/,anum/5*0/,aaer/5*0/,asubr/5*0/,asol/5*0/
C.. AFGEN FUNCTION PERFORMS LINEAR INTERPOLATION ON DATA SETS TO RETURN
C   VALUES AT THE APPROPRIATE TIME THE MODEL REQUIRES.
      tamb=afgen(aair,iatemp,time,atemp)
      windspd=afgen(awin,iwind,time,wind)
      rhumid=afgen(arhu,ihumid,time,humid)
      clouds=afgen(aclo,icloud,time,cloud)
      wwflow=afgen(awwf,iinfflo,time,infflow)
      intemp=afgen(aint,iinftemp,time,inftemp)
      subremrt=afgen(asubr,isbremrt,time,sbremrt)
C.. POLYNONMIAL EQUATIONS FOR PHYSICAL CONSTANTS THAT ARE
C   TEMPERATURE DEPENDENT
      airdens=(0.001293/(1+0.00367*tamb))*1000
      wtrdens=999.856+0.058088*twinit-7.81419e-3*twinit**2+3.98694e-5*
     1twinit**3
      sphtair=(0.246004+5.8129e-5*tamb+2.44014e-6*tamb**2-7.85452e-8*
     1tamb**3+8.53318e-10*tamb**4-3.15067e-12*tamb**5)*1000
      sphtwtr=(1.00721-8.1362e-4*twinit+2.68624e-5*twinit**2-4.28432e-7*
     1twinit**3+3.50166e-9*twinit**4-1.09329e-11*twinit**5)*1000
      LHV=(595.66886002-0.53228271618*twinit+8.6706135756e-05*
     1twinit**2)*1000
      Vapair=4.6667+0.33498*tamb+0.0097951*tamb**2+2.0664e-04*tamb**3
     1+3.3009E-06*tamb**4
      Vapbasin=4.6667+0.33498*twinit+0.0097951*twinit**2+2.0664e-04*
     1twinit**3+3.3009E-06*twinit**4
      reflwtr=0.03
      emiswtr=.97
C.. NET HEAT GAIN FROM SHORT WAVE SOLAR RADIATION
      if (solrad(1,2).eq.0)then
        call solar (time,lat,long,hswsr0)
       else
        hswsr0=afgen(asol,isolrad,time,solrad)
      endif
      hswsr=hswsr0*(1-0.0071*clouds**2)*barea
C.. ENERGY EXCHANGE FROM LONGWAVE (INFRARED) SOLAR RADIATION.
      a=0.7399300762+0.010352672786*clouds-1.9812639499e-05*clouds**2
      b=(0.14729812741-5.6951848819e-05*clouds**3)/10
      beta=a+b*vapair*0.5357756
      hlwsr = (emiswtr * 1.17e-3 * (twinit + 273)**4 * barea)
     1- ((1 - reflwtr) * beta * 1.17e-3 * (tamb + 273)**4 *
```

```
     2barea)
C.. ENERGY EXCHANGE FROM EVAPORATION AT BASIN SURFACE.
      hevap = (1.145e6 * (1 - rhumid/100) + 6.86e4 * (twinit -
     1tamb)) * exp (0.0604 * tamb) * windspd * barea **0.95
C.. ENERGY EXCHANGE FROM CONVECTION AT BASIN SURFACE.
      hconv = airdens * sphtair * 392 * barea**(0.95) *
     1windspd * (twinit - tamb)
C.. ENERGY EXCHANGE FROM AERATION, THIS IS THE SUM OF LATENT AND
C   SENSIBLE HEATS.
C.. LATENT PORTION
      humifact=1.0
      numbaer=afgen(anum,inumaer,time,numaer)
      aerarea=afgen(aaer,isprarea,time,sprarea)
      gasflowu=numbaer*aerarea*windspd
      hlatentu = (18 * gasflowu * lhv)/(100 * 62.361) * 86400 *
     1((vapbasin * (rhumid + humifact * (100 - rhumid))
     2/(twinit + 273)) - (vapair * rhumid)/(tamb + 273))
      airflow=afgen(aairf,iairflo,time,airflo)
      gasflowd=airflow
      hlatentd = (18 * gasflowd * lhv)/(100 * 62.361) * 86400 *
     1((vapbasin * (rhumid + (100 - rhumid))
     2/(twinit + 273)) - (vapair * rhumid)/(tamb + 273))
      hlatent=hlatentu+hlatentd
C.. SENSIBLE PORTION
      if(numbaer.eq.0..or.aerarea.eq.0.)then
        hsensblu=0
      else
        hsensblu = (392 * numbaer*aerarea **(-0.05) * windspd) * barea *
     1  airdens * sphtair * (twinit - tamb)
      endif
      hsensbld = airflow * airdens * sphtair * 86400 *
     1(twinit - tamb)
      hsensbl=hsensblu+hsensbld
      haer = hlatent + hsensbl
C.. ENERGY EXCHANGE FROM TANK WALL, BOTH ABOVE AND BELOW
C   GROUND EXPOSURE.
      htwair = htcoair * areaair * (twinit - tamb)
      htwgrd = htcogrd * (areagrd+barea) * (twinit - tgrd)
      htnkwal = htwair + htwgrd
C.. ENERGY EXCHANGE FROM POWER INPUT (SURFACE AERATOR OR
C   DIFFUSED AIR)
      hpwrd = 15398784 * powerd* (1 - effd/100)
      hpwrs = 15398784 * powers* (effs/100)
      hpwr=hpwrs+hpwrd
C.. ENERGY EXCHANGE FROM BIOLOGICAL REACTION.
      hbiorxn = (3.3 - 5.865 * cellyld) * 1e06 * subremrt
C.. SUM OF ENERGY EXCHANGE TERMS
      sumofh=hswsr+hpwr+hbiorxn-hlwsr-hevap-hconv-haer-htnkwal
C.. OVERALL ENERGY BALANCE EQUATION SOLVED EXPLICITLY FOR CHANGE
C   IN BASIN TAMPERATURE.
      hcont=wtrdens * sphtwtr * wwflow * (twinit - intemp)
      dTwdt = (sumofh - hcont)/ (wtrdens * sphtwtr * volume)
      return
      end
```

```fortran
      function afgen(ax,n,x,arr)
************************************************************************
*  This function generates an arbitrary function defined by pairs of   *
*  data points contained in the array arr, with the number of points=n.*
*  note that the function checks for proper data entry on the first    *
*  call, and checks to see if x is in the range defined data contained *
*  in by the arr array. linear interpolation is used.                  *
************************************************************************
      integer ax(5)
      dimension arr(100,2)
C.. CHECK FOR INITIAL ENTRY
c      write(*,*) ax(4),n
      if(ax(4)) 30,10,30
10    if(n-1) 11,11,12
11    write(6,1000) n
1000  format(//,' less than two data points were supplied for an afgen',
     1' function',//,' execution terminating')
      stop 31
12    ax(4)=1
C.. CHECK TO SEE IF THE DATA WAS ENTERED CORRECTLY IN ASCENDING ORDER
      do 13 i=2,n
13    if(arr(i,1).le.arr((i-1),1)) goto 14
      goto 15
14    k=i-1
      write(6,1010) i,arr(i,1),k,arr(k,1)
1010  format(//,' the independent variable for an afgen function has ',
     1'not been',/,' entered in ascending order',/,' the',i3,'th point='
     2,2x,e17.6,2x,'while the',i3,'th point=',2x,e17.6,/,' execution ter
     3minating')
      stop 32
15    ax(1)=0.
      if(x.lt.arr(1,1)) ax(1)=1
      if(x.gt.arr(n,1)) ax(1)=-1.
      if(ax(1)) 16,17,16
16    write(6,1020) x,arr(1,1),arr(n,1)
1020  format(' the initial entry to an afgen function is out of range',
     1/,' the value of the independent variable is',e17.6,' while the',
     2/,' minimum value of the function is',e17.6, ' and the maximum',
     3/,' value of the function is',e17.6)
      if(ax(4)) 82,17,92
17    i=1
18    if(arr(i,1).ge.x) goto 20
      i=i+1
      goto 18
20    if(i.eq.1) goto 70
      i=i-1
      if(arr(i,1).lt.x) goto 70
      goto 20
C.. NORMAL ENTRY FOR AFGEN
30    if(x.lt.arr(1,1).or.x.gt.arr(n,1)) goto 80
      i=ax(2)
40    if(arr(i,1).ge.x) goto 50
      i=i+1
      goto 40
50    i=i-1
60    if(arr(i,1).le.x) goto 70
      goto 50
70    i=i+1
      ax(2)=i
      afgen=arr((i-1),2)+(x-arr((i-1),1))*(arr(i,2)-arr((i-1),2))/
```

```
     1(arr(i,1)-arr((i-1),1))
      ax(4)=1.
      goto 100
80    if(x.lt.arr(n,1)) goto 90
      if(ax(4)) 87,82,82
82    time=x
      write(6,1030) time,x,arr(n,1)
1030  format(' independent variable for afgen function above range at',
     1' time=',e12.6,/,' independent variable=',e12.6,' maximum for this
     2 afgen function=',e12.6)
87    afgen=arr(n,2)
      ax(4)=-1
      ax(2)=n
      goto 100
90    if(ax(4)) 97,92,92
92    write(6,1040) time,x,arr(1,1)
1040  format(' independent variable for afgen function below range at',
     1' time=',e12.6,/,' independent variable=',e12.6,' minimum for this
     2 afgen function=',e12.6)
97    ax(2)=1
      ax(4)=-1
      afgen=arr(1,2)
100   return
      end




************************************************************************
*            Calculates the clear sky solar radiation and all          *
*               necessary intermediate parameters.                     *
************************************************************************
      Subroutine Solar (time,lat,long,hswsr0)
      real l, n, lamda, lat, long
      degtorad=57.29577951
      degtotim=15
      radtotim=3.819718634
C.. DAY NUMBER - NUMBER OF DAYS FROM JULIAN DATE J2000.0
      n = -2923.5 + time
C.. MEAN ANOMALY
      g=357.528 + 0.9856003 * n
C.. PLACES G IN THE 0 TO 360 DEGREE RANGE BY ADDING
C   MULTIPLES OF 360.
      if (g .lt. 0. .or. g .gt. 360.) then
        dum = (aint(abs (g/360.))+1.)*360.
        g = g + dum
      end if
C.. MEAN LONGITUDE
      l = 280.460 + 0.9856474 * n
C.. PLACES L IN THE 0 TO 360 DEGREE RANGE BY ADDING
C   MULTIPLES OF 360.
      if (l .lt. 0. .or. l .gt. 360.) then
        dum = (aint(abs (l/360.))+1.)*360.
        l = l + dum
      end if
C.. ECLIPTIC LONGITUDE
      lamda = l + 1.915 * sin (g/degtorad) + 0.020 * sin (2*g/degtorad)
C.. OBLIQUITY OF ECLIPTIC
```

```
      epsilon = 23.439 - 0.0000004 * n
C.. RIGHT ASCENSION
      alpha = lamda - degtorad * (tan (epsilon/(2.*degtorad)))**2 * sin
     1(2.*(g/degtorad)) + (degtorad/2.) * (tan (epsilon/(2.*degtorad)))
     2**4 * sin(4.*lamda/degtorad)
C.. SOLAR DECLINATION
      delta = degtorad*asin(sin(epsilon/degtorad)*sin (lamda/degtorad))
      stime=gethour(time)
C.. HOUR ANGLE
      htime=(stime - long/degtotim)
      if (htime .lt. 0.) then
        htime = htime+24.
      endif
      hourangl=-180. + 15. * htime
C.. COS OF THE ZENITH ANGLE DEFINED AS:
      cosz = sin (lat/degtorad) * sin (delta/degtorad) + cos
     1(lat/degtorad) * cos (delta/degtorad) *
     2cos (hourangl/degtorad)
C.. SOLAR ALTITUDE (COMPLEMENT OF THE ZENITH ANGLE)
      alt=asin(cosz)*degtorad
C.. CHECK FOR SUN, CALCULATE RADIATION IF UP, SET TO ZERO IF DOWN
      if (alt.gt.0.)then
C.. OVERALL CLEAR SKY SOLAR RADIATION EQUATION.
        hswsr0 = (-0.6401+1.3341*alt+0.2008*alt**2-0.0043*alt**3
     1            +3.79e-05*alt**4-1.37e-07*alt**5)*65102.26
      else
        hswsr0=0
      endif
      return
      end

********************************************************************
            Timeftn
********************************************************************
C.. THIS FUNCTION RETURNS THE HOUR FROM A REAL VARIABLE
      function gethour(dofy)
      idofy=dofy
      gethour=24.*(dofy-float(idofy))
      return
      end
```

```
C.. THIS FUNCTION RETURNS THE HOUR FROM A REAL VARIABLE
      function gethour(dofy)
      idofy=dofy
      gethour=24.*(dofy-float(idofy))
      return
      end
```

Special Main Program for HPO Plants (Sacramento)

```
************************************************************************
*            Dynamic Model for the Prediction of Temperature           *
*                     in a Wastewater Aeration Basin                   *
*                                 By                                   *
*                            Paul Sedory                               *
*                                                                      *
************************************************************************
```

```
C.. MAIN PROGRAM
      real atemp(100,2),wind(100,2),humid(100,2),cloud
     1(100,2),infflow(100,2),inftemp(100,2),airflo(100,2),numaer(100,2)
     2,sprarea(100,2),sbremrt(100,2),solrad(100,2),lat,long
C.. HEADINGS FOR TEMPERATURE OUTPUT FILE AND HEAT TERM OUTPUT FILE.
      open (9,file='final.dat')
      write(9,2000)
2000  format (1x,'Time',2x,'Temperature')
      open (10,file='heats.dat')
      write (10,2001)
2001  format (2x,'time',6x,'hlwsr',7x,'hevap',7x,'hconv',7x,'haer',8x,
     1'htnkwal',5x,'hswsr',7x,'hpwr',8x,'hbiorxn',5x,'sumofh')
C.. READS IN CONSTANTS FILE
      open (8,file='constant.dat')
      read (8,1000) lat,long,tgrd,barea,volume,areaair,htcoair,areagrd,
     1htcogrd,powers,effs,powerd,effd,cellyld,sdate,duration,printerv,
     2stwinit,cbarea
1000  format (3(f8.0,/),/,11(f8.0,/),/,4(f8.0,/),f8.0)
      close (8)
C.. OPEN AND OUTPUT FILE AND WRITE INPUT DATA
      open (7,file='output.dat')
      write (7,1001) lat,long, tgrd,
     1barea,volume, areaair, htcoair, areagrd, htcogrd, powers, effs,
     2powerd,effd, cellyld, sdate, duration, printerv,stwinit
1001  format ('Latitude= ',f6.2/,'Longitude= ',f6.2/,'Ground '
     1'Temperature= ',f5.2/,'Basin Surface Area= ',f8.0/,'Basin '
     2'Volume= ',f8.0/,'Submerged Wall Area Exposed to Air= ',f8.0/,
     4'Heat Transfer Coefiicient to Air= ',f7.0/,'Submerged Wall Area'
     5' Exposed to Ground= ',f8.0/,'Heat Transfer Coefficient'
     6' to Ground= ',f7.0/,'Power Input to Aerator= ',f7.1/,'Efficiency'
     7' of Aerator= ',f4.0/,'Power Input to Compressor= ',f7.1/,
     8'Efficiency of Compressor= ',f4.0/,'Cell Yield= ',f4.2/,
     9'Start Date= ',f8.4/,'Model Duration= ',f8.4/,'Print Time'
     1' Interval= ',f8.4/,'Initial Basin Temperature Estimate= ',f5.2)
C.. AIR TEMPERATURE ARRAY
      open (8, file='airtemp.dat')
      do 10, I=1,100
       read (8, 1010, end=20) atemp(I,1), atemp(I,2)
10    iatemp=I
1010  format (f8.0,2x,f12.0)
20    write (7,1011) (atemp(I,1), atemp(I,2), I=1,Iatemp)
1011  format (1x, 'Air temperature data'/1x,'DateTime',1x,'Temperature'
     1,/,100(f8.4,2x,f8.2,/))
C.. WIND SPEED ARRAY
      open (8, file='windspd.dat')
```

```
      do 30, I=1,100
       read (8, 1010, end=40) wind(I,1), wind(I,2)
30    Iwind=I
40    write (7,1020) (wind(I,1), wind(I,2), I=1,iwind)
1020  format (1x, 'Wind Speed data'/1x,'DateTime',1x,'Wind Speed'
     1,/,100(f8.4,2x,f8.1,/))
C.. RELATIVE HUMIDITY ARRAY
      open (8, file='rhumid.dat')
      do 50, I=1,100
       read (8, 1010, end=60) humid(I,1), humid(I,2)
50    Ihumid=I
60    write (7,1030) (humid(I,1), humid(I,2), I=1,ihumid)
1030  format (1x, 'Relative Humidity data'/1x,'DateTime',1x,'Humidity'
     1,/,100(f8.4,2x,f8.0,/))
C.. CLOUD COVER ARRAY
      open (8, file='clouds.dat')
      do 70, I=1,100
       read (8, 1010, end=80) cloud(I,1), cloud(I,2)
70    Icloud=I
80    write (7,1040) (cloud(I,1), cloud(I,2), I=1,icloud)
1040  format (1x, 'Cloud Cover data'/1x,'DateTime',1x,'Cloud Cover'
     1,/,100(f8.4,2x,f8.1,/))
C.. INFLUENT FLOW ARRAY
      open (8, file='wwflow.dat')
      do 90, I=1,100
       read (8, 1010, end=100) infflow(I,1), infflow(I,2)
90    Iinfflo=I
100   write (7,1050) (infflow(I,1), infflow(I,2), I=1,iinfflo)
1050  format (1x, 'Influent Flowrate data'/1x,'DateTime',1x,'Influent
     1Flowrate',/,100(f8.4,2x,f8.0,/))
C.. INFLUENT TEMPERATURE ARRAY
      open (8, file='intemp.dat')
      do 110, I=1,100
       read (8, 1010, end=120) inftemp(I,1), inftemp(I,2)
110   Iinftemp=I
120   write (7,1060) (inftemp(I,1), inftemp(I,2), I=1,iinftemp)
1060  format (1x, 'Influent Temperature data'/1x,'DateTime',1x,
     1'Influent Temperature',/,100(f8.4,2x,f8.1,/))
C.. DIFFUSED AIR FLOWRATE ARRAY
      open (8, file='airflow.dat')
      do 130, I=1,100
       read (8, 1010, end=140) airflo(I,1), airflo(I,2)
130   iairflo=i
140   write (7,1070) (airflo(I,1), airflo(I,2), I=1,iairflo)
1070  format (1x, 'Diffused Air Flowrate data'/1x,'DateTime',1x,
     1'Air Flowrate',/,100(f8.4,2x,f8.4,/))
C.. NUMBER OF AERATORS ARRAY
      open (8, file='numbaer.dat')
      do 150, I=1,100
       read (8, 1010, end=160) numaer(I,1), numaer(I,2)
150   Inumaer=I
160   write (7,1080) (numaer(I,1), numaer(I,2), I=1,inumaer)
1080  format (1x, 'Number of Aerators data'/1x,'DateTime',1x,
     1'Number of Aerators',/,100(f8.4,2x,f8.1,/))
C.. AERATOR SPRAY AREA ARRAY
      open (8, file='aerarea.dat')
      do 170, I=1,100
       read (8, 1010, end=180) sprarea(I,1), sprarea(I,2)
170   Isprarea=I
180   write (7,1090) (sprarea(I,1), sprarea(I,2), I=1,isprarea)
```

```
1090  format (1x, 'Spray Area data'/1x,'DateTime',1x,'Spray Area'
     1,/,100(f8.4,2x,f8.1,/))
C.. SOLAR RADIATION ARRAY
      open (8, file='solarad.dat')
      do 190, I=1,100
       read (8, 1010, end=200) solrad(I,1), solrad(I,2)
190   Isolrad=I
200   write (7,1100) (solrad(I,1), solrad(I,2), I=1,isolrad)
1100  format (1x, 'Solar Radiation Data'/1x,'DateTime',1x,
     1'Solar Radiation',/,100(f8.4,2x,f8.0,/))
C.. SUBSTRATE REMOVAL RATE ARRAY
      open (8, file='subremrt.dat')
      do 210, I=1,100
       read (8, 1010, end=220) sbremrt(I,1), sbremrt(I,2)
210   Isbremrt=I
      close (8)
220   write (7,1110) (sbremrt(I,1), sbremrt(I,2), I=1,isbremrt)
1110  format (1x, 'Substrate Removal Rate data'/1x,'DateTime',1x,
     1'Substrate Removal Rate',/,100(f8.4,2x,f8.0,/))
C.. CALLS SUBROUTINE TO DETERMINE EQUILIBRIUM TEMPERATURE TO USE AS
C   INITIAL TEMPERATURE FOR DYNAMIC MODELING.
      time=sdate
      call init(lat,long,atemp(1,2),wind(1,2),humid(1,2),
     1cloud(1,2),powerd,effd,powers,effs,htcoair,htcogrd,
     2cellyld,infflow(1,2),inftemp(1,2),airflo(1,2),numaer(1,2),
     3sprarea(1,2),sbremrt(1,2),stwinit,barea,time
     4,areaair,areagrd,tgrd,twinit,solrad(1,2),cbarea)
C.. PARAMETER INITIALIZATION
      timestep=0.041
      ptime=sdate
C.. CALL SUBROUTINE TO CALCULATE DTWDT AND THEN PERFORM 2ND ORDER
NUMERICAL
C    INTEGRATION
250   continue
      call sumh(lat,long,atemp,wind,humid,cloud,powerd,effd,cbarea,
     1powers,effs,htcoair,htcogrd,cellyld,infflow,inftemp,
     2airflo,numaer,sprarea,sbremrt,twinit,barea,volume,time,dTwdt,
     3areaair,areagrd,tgrd,iatemp,iwind,ihumid,icloud,iinfflo,
     4inumaer,isprarea,isbremrt,iinftemp,iairflo,beta,solrad,isolrad,
     5hlwsr,hevap,hconv,haer,htnkwal,hswsr,hpwr,hbiorxn,sumofh)
      Thalf=Twinit+timestep/2.*dTwdt
      TwinitA=Twinit
      Twinit=Thalf
      call sumh(lat,long,atemp,wind,humid,cloud,powerd,effd,cbarea,
     1powers,effs,htcoair,htcogrd,cellyld,infflow,inftemp,
     2airflo,numaer,sprarea,sbremrt,twinit,barea,volume,time,dTwdt,
     3areaair,areagrd,tgrd,iatemp,iwind,ihumid,icloud,iinfflo,
     4inumaer,isprarea,isbremrt,iinftemp,iairflo,beta,solrad,isolrad,
     5hlwsr,hevap,hconv,haer,htnkwal,hswsr,hpwr,hbiorxn,sumofh)
      Tfull=TwinitA+timestep*dTwdt
      Twinit=Tfull
C.. CHECK TO SEE IF TEMPERATURE SHOULD BE PRINTED AND CHECK MODEL
DURATION
C    TO DETERMINE CONTINUATION OF PROGRAM
      if (time.ge.ptime) then
        write(9,2010) time,tfull
2010    format (1x,f6.2,2x,f6.3)
C.. PRINTS HEAT TERM DATA TO OUTPUT FILE
        write (10,2050) time,hlwsr,hevap,hconv,haer,
     1  htnkwal,hswsr,hpwr,hbiorxn,sumofh
```

```
2050    format (f8.4,2x,9(e10.4,2x))
          ptime=ptime+printerv
        endif
        time=time+timestep
        if (time.lt.(sdate+duration))then
          goto 250
        endif
        Write (*,*) 'This program has successfully completed'
        end
```

APPENDIX D

INPUT DATA

Milwaukee - January Input Files

Latitude	42
Longitude	88
Ground Temperature	5
Basin Surface Area	19177
Basin Volume	87699
Submerged Wall Area Exposed to Air	0
Heat Transfer Coefiicient to Air	0
Submerged Wall Area Exposed to Groun	4125
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	0
Efficiency ofAerator	0
Power Input to Compressor	2750
Efficiency of Compressor	15
Cell Yield	0.46
Start Date	1.75
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	12

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
1.2500	.00	1.2500	3.1	1.2500	79.	1.2500	10.0
1.5833	-.60	1.5833	2.1	1.5833	85.	1.5833	10.0
1.9167	.00	1.9167	2.6	1.9167	92.	1.9167	10.0
2.2500	1.10	2.2500	2.6	2.2500	89.	2.2500	10.0
2.5833	2.20	2.5833	3.1	2.5833	85.	2.5833	10.0
2.9167	3.90	2.9167	3.1	2.9167	96.	2.9167	10.0
3.2500	3.90	3.2500	2.1	3.2500	100.	3.2500	10.0
3.5833	3.30	3.5833	2.1	3.5833	100.	3.5833	10.0
3.9167	3.90	3.9167	3.1	3.9167	89.	3.9167	10.0
4.2500	1.70	4.2500	4.1	4.2500	85.	4.2500	10.0
4.5833	1.70	4.5833	4.1	4.5833	79.	4.5833	10.0
4.9167	1.70	4.9167	3.1	4.9167	82.	4.9167	10.0
5.2500	2.20	5.2500	4.6	5.2500	76.	5.2500	10.0
5.5833	2.20	5.5833	3.1	5.5833	73.	5.5833	10.0
5.9167	1.70	5.9167	3.1	5.9167	76.	5.9167	10.0
6.2500	.60	6.2500	2.6	6.2500	82.	6.2500	10.0
6.5833	.60	6.5833	3.1	6.5833	89.	6.5833	10.0
6.9167	2.20	6.9167	5.7	6.9167	85.	6.9167	10.0
7.2500	1.10	7.2500	3.6	7.2500	76.	7.2500	10.0
7.5833	1.10	7.5833	2.1	7.5833	70.	7.5833	10.0
7.9167	2.80	7.9167	3.1	7.9167	67.	7.9167	10.0
8.2500	2.80	8.2500	5.7	8.2500	73.	8.2500	10.0
8.5833	2.20	8.5833	6.7	8.5833	85.	8.5833	10.0
8.9167	2.80	8.9167	3.6	8.9167	93.	8.9167	10.0
9.2500	3.90	9.2500	3.1	9.2500	96.	9.2500	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
9.5833	2.80	9.5833	7.2	9.5833	89.	9.5833	10.0
9.9167	3.30	9.9167	5.7	9.9167	76.	9.9167	10.0
10.2500	1.10	10.2500	5.1	10.2500	76.	10.2500	10.0
10.5833	-2.80	10.5833	5.1	10.5833	66.	10.5833	10.0
10.9167	.60	10.9167	6.2	10.9167	54.	10.9167	8.0
11.2500	.00	11.2500	6.7	11.2500	75.	11.2500	8.0
11.5833	-.60	11.5833	3.1	11.5833	85.	11.5833	1.0
11.9167	6.10	11.9167	5.1	11.9167	65.	11.9167	.0
12.2500	3.90	12.2500	6.2	12.2500	73.	12.2500	4.0
12.5833	3.30	12.5833	7.7	12.5833	70.	12.5833	10.0
12.9167	2.80	12.9167	5.7	12.9167	93.	12.9167	10.0
13.2500	3.90	13.2500	6.7	13.2500	93.	13.2500	10.0
13.5833	1.70	13.5833	3.6	13.5833	89.	13.5833	10.0
13.9167	-.60	13.9167	9.3	13.9167	82.	13.9167	10.0
14.2500	-5.00	14.2500	9.8	14.2500	75.	14.2500	10.0
14.5833	-7.20	14.5833	7.7	14.5833	65.	14.5833	6.0
14.9167	-4.40	14.9167	5.7	14.9167	50.	14.9167	8.0
15.2500	-7.80	15.2500	3.6	15.2500	65.	15.2500	5.0
15.5833	-9.40	15.5833	8.2	15.5833	84.	15.5833	10.0
15.9167	-13.30	15.9167	8.7	15.9167	52.	15.9167	1.0
16.2500	-20.00	16.2500	7.2	16.2500	62.	16.2500	.0
16.5833	-18.90	16.5833	5.1	16.5833	65.	16.5833	10.0
16.9167	-8.30	16.9167	8.2	16.9167	65.	16.9167	10.0
17.2500	-2.80	17.2500	6.2	17.2500	75.	17.2500	10.0
17.5833	-5.60	17.5833	7.2	17.5833	65.	17.5833	10.0
17.9167	-6.10	17.9167	8.2	17.9167	42.	17.9167	.0
18.2500	-13.30	18.2500	5.7	18.2500	52.	18.2500	.0
18.5833	-17.80	18.5833	7.2	18.5833	51.	18.5833	.0
18.9167	-12.20	18.9167	7.2	18.9167	39.	18.9167	.0
19.2500	-16.10	19.2500	4.6	19.2500	60.	19.2500	.0
19.5833	-17.20	19.5833	4.6	19.5833	62.	19.5833	8.0
19.9167	-6.10	19.9167	6.2	19.9167	65.	19.9167	10.0
20.2500	-4.40	20.2500	6.7	20.2500	69.	20.2500	10.0
20.5833	-11.70	20.5833	4.6	20.5833	70.	20.5833	.0
20.9167	-2.80	20.9167	7.2	20.9167	53.	20.9167	4.0
21.2500	-1.10	21.2500	3.6	21.2500	72.	21.2500	.0
21.5833	-2.80	21.5833	2.1	21.5833	85.	21.5833	8.0
21.9167	1.70	21.9167	4.6	21.9167	76.	21.9167	10.0
22.2500	-1.10	22.2500	2.6	22.2500	92.	22.2500	10.0
22.5833	1.70	22.5833	5.1	22.5833	85.	22.5833	10.0
22.9167	3.90	22.9167	4.1	22.9167	73.	22.9167	10.0
23.2500	1.10	23.2500	5.1	23.2500	96.	23.2500	10.0
23.5833	1.70	23.5833	5.1	23.5833	85.	23.5833	10.0
23.9167	-3.90	23.9167	10.3	23.9167	78.	23.9167	10.0
24.2500	-8.30	24.2500	10.3	24.2500	68.	24.2500	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
24.5833	-10.60	24.5833	7.7	24.5833	64.	24.5833	.0
24.9167	-6.10	24.9167	5.1	24.9167	38.	24.9167	.0
25.2500	-7.80	25.2500	2.1	25.2500	49.	25.2500	10.0
25.5833	-3.30	25.5833	5.7	25.5833	88.	25.5833	10.0
25.9167	-2.80	25.9167	4.1	25.9167	81.	25.9167	10.0
26.2500	-5.60	26.2500	6.2	26.2500	78.	26.2500	10.0
26.5833	-8.30	26.5833	2.6	26.5833	84.	26.5833	10.0
26.9167	-2.20	26.9167	4.1	26.9167	66.	26.9167	10.0
27.2500	-3.30	27.2500	5.1	27.2500	85.	27.2500	3.0
27.5833	-3.90	27.5833	5.1	27.5833	85.	27.5833	.0
27.9167	-1.70	27.9167	5.7	27.9167	82.	27.9167	10.0
28.2500	-2.20	28.2500	3.6	28.2500	75.	28.2500	10.0
28.5833	-1.70	28.5833	2.1	28.5833	78.	28.5833	10.0
28.9167	-1.10	28.9167	4.1	28.9167	72.	28.9167	10.0
29.2500	-2.80	29.2500	7.2	29.2500	89.	29.2500	10.0
29.5833	-3.30	29.5833	6.7	29.5833	92.	29.5833	10.0
29.9167	.60	29.9167	7.2	29.9167	82.	29.9167	8.0
30.2500	-.60	30.2500	4.6	30.2500	89.	30.2500	2.0
30.5833	1.70	30.5833	4.6	30.5833	89.	30.5833	10.0
30.9167	3.90	30.9167	4.1	30.9167	73.	30.9167	10.0
31.2500	2.20	31.2500	2.6	31.2500	76.	31.2500	10.0
31.5833	1.10	31.5833	4.6	31.5833	89.	31.5833	10.0
31.9167	.00	31.9167	6.7	31.9167	59.	31.9167	10.0

Influent Flowrate data		Influent Temperature data		Diffused Air Flowrate dat		Substrate Removal Rate	
DateTime	Influent Flow	DateTime	Influent Temp	DateTime	Air Flowrate	DateTime	Sub.Removal
1.7500	280090.	1.7500	13.9	1.7500	19.	1.7500	10083.
2.7500	291445.	2.7500	13.9	2.7500	19.	2.7500	13989.
3.7500	317940.	3.7500	13.9	3.7500	21.	3.7500	19394.
4.7500	317940.	4.7500	13.9	4.7500	21.	4.7500	18123.
5.7500	314155.	5.7500	13.9	5.7500	21.	5.7500	16650.
6.7500	333080.	6.7500	13.9	6.7500	21.	6.7500	17986.
7.7500	329295.	7.7500	13.9	7.7500	22.	7.7500	18111.
8.7500	355790.	8.7500	13.9	8.7500	21.	8.7500	21347.
9.7500	404995.	9.7500	13.9	9.7500	24.	9.7500	13770.
10.7500	389855.	10.7500	13.3	10.7500	26.	10.7500	23781.
11.7500	378500.	11.7500	13.3	11.7500	26.	11.7500	20439.
12.7500	363360.	12.7500	13.3	12.7500	22.	12.7500	17805.
13.7500	374715.	13.7500	13.3	13.7500	21.	13.7500	18736.
14.7500	363360.	14.7500	13.3	14.7500	23.	14.7500	19621.
15.7500	348220.	15.7500	13.3	15.7500	23.	15.7500	18456.
16.7500	340650.	16.7500	13.3	16.7500	23.	16.7500	20780.
17.7500	333080.	17.7500	13.3	17.7500	23.	17.7500	22316.
18.7500	321725.	18.7500	13.3	18.7500	23.	18.7500	19625.
19.7500	310370.	19.7500	13.3	19.7500	22.	19.7500	19864.
20.7500	317940.	20.7500	13.3	20.7500	18.	20.7500	19712.
21.7500	317940.	21.7500	13.3	21.7500	21.	21.7500	22574.
22.7500	306585.	22.7500	13.9	22.7500	21.	22.7500	22381.
23.7500	329295.	23.7500	13.3	23.7500	23.	23.7500	20087.
24.7500	310370.	24.7500	13.3	24.7500	24.	24.7500	67971.
25.7500	295230.	25.7500	13.3	25.7500	22.	25.7500	24799.
26.7500	287660.	26.7500	13.3	26.7500	22.	26.7500	21575.
27.7500	295230.	27.7500	13.3	27.7500	22.	27.7500	21552.
28.7500	291445.	28.7500	13.3	28.7500	22.	28.7500	19235.
29.7500	295230.	29.7500	13.3	29.7500	24.	29.7500	22142.
30.7500	291445.	30.7500	13.3	30.7500	23.	30.7500	24773.
31.7500	291445.	31.7500	13.9	31.7500	24.	31.7500	24481.

Spray Area data

DateTime	Spray Area
1.7500	.0
31.7500	.0

Number of Aerators data

DateTime	Number of Aerators
1.7500	.0
31.7500	.0

Solar Radiation Data

DateTime	Solar Radiation
1.2500	0.
31.2500	0.

Milwaukee - July Input Files

Latitude	42
Longitude	88
Ground Temperature	18
Basin Surface Area	20157
Basin Volume	93829
Submerged Wall Area Exposed to Air	0
Heat Transfer Coeficient to Air	0
Submerged Wall Area Exposed to Groun	4125
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	0
Efficiency ofAerator	0
Power Input to Compressor	2750
Efficiency of Compressor	15
Cell Yield	0.29
Start Date	183.7083
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	19

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
183.2083	17.20	183.2083	2.6	183.2083	93.	183.2083	7.0
183.5417	23.30	183.5417	5.7	183.5417	87.	183.5417	10.0
183.8750	25.00	183.8750	4.1	183.8750	88.	183.8750	8.0
184.2083	18.90	184.2083	2.1	184.2083	100.	184.2083	10.0
184.5417	25.60	184.5417	3.1	184.5417	77.	184.5417	6.0
184.8750	33.30	184.8750	5.7	184.8750	29.	184.8750	3.0
185.2083	22.80	185.2083	5.1	185.2083	76.	185.2083	3.0
185.5417	26.70	185.5417	4.1	185.5417	47.	185.5417	.0
185.8750	25.60	185.8750	5.1	185.8750	67.	185.8750	8.0
186.2083	21.10	186.2083	3.6	186.2083	76.	186.2083	4.0
186.5417	22.80	186.5417	5.1	186.5417	66.	186.5417	4.0
186.8750	26.70	186.8750	6.7	186.8750	52.	186.8750	7.0
187.2083	20.00	187.2083	3.6	187.2083	84.	187.2083	4.0
187.5417	23.30	187.5417	4.1	187.5417	69.	187.5417	.0
187.8750	30.60	187.8750	4.1	187.8750	42.	187.8750	3.0
188.2083	21.70	188.2083	1.5	188.2083	79.	188.2083	.0
188.5417	26.10	188.5417	5.1	188.5417	69.	188.5417	8.0
188.8750	32.20	188.8750	2.6	188.8750	52.	188.8750	9.0
189.2083	26.70	189.2083	3.6	189.2083	60.	189.2083	3.0
189.5417	25.60	189.5417	3.6	189.5417	52.	189.5417	5.0
189.8750	20.00	189.8750	2.1	189.8750	93.	189.8750	10.0
190.2083	22.20	190.2083	6.2	190.2083	79.	190.2083	3.0
190.5417	20.60	190.5417	6.7	190.5417	76.	190.5417	4.0
190.8750	20.60	190.8750	5.1	190.8750	63.	190.8750	7.0
191.2083	18.90	191.2083	2.1	191.2083	76.	191.2083	8.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
191.5417	21.70	191.5417	4.6	191.5417	61.	191.5417	10.0
191.8750	23.90	191.8750	6.2	191.8750	50.	191.8750	8.0
192.2083	21.10	192.2083	2.1	192.2083	68.	192.2083	9.0
192.5417	22.80	192.5417	2.6	192.5417	69.	192.5417	10.0
192.8750	25.00	192.8750	3.6	192.8750	67.	192.8750	4.0
193.2083	21.10	193.2083	2.1	193.2083	84.	193.2083	4.0
193.5417	23.30	193.5417	5.1	193.5417	71.	193.5417	1.0
193.8750	25.60	193.8750	4.6	193.8750	58.	193.8750	4.0
194.2083	23.90	194.2083	5.1	194.2083	76.	194.2083	10.0
194.5417	22.80	194.5417	2.6	194.5417	97.	194.5417	10.0
194.8750	28.30	194.8750	8.7	194.8750	63.	194.8750	9.0
195.2083	20.00	195.2083	6.2	195.2083	84.	195.2083	10.0
195.5417	18.90	195.5417	7.7	195.5417	78.	195.5417	10.0
195.8750	21.10	195.8750	8.2	195.8750	79.	195.8750	8.0
196.2083	18.90	196.2083	7.2	196.2083	70.	196.2083	.0
196.5417	20.00	196.5417	4.6	196.5417	68.	196.5417	.0
196.8750	23.30	196.8750	4.6	196.8750	48.	196.8750	.0
197.2083	16.70	197.2083	.0	197.2083	84.	197.2083	.0
197.5417	22.80	197.5417	2.6	197.5417	52.	197.5417	.0
197.8750	25.00	197.8750	5.7	197.8750	52.	197.8750	.0
198.2083	20.00	198.2083	3.6	198.2083	78.	198.2083	.0
198.5417	24.40	198.5417	3.6	198.5417	58.	198.5417	.0
198.8750	31.70	198.8750	6.2	198.8750	38.	198.8750	7.0
199.2083	23.90	199.2083	5.1	199.2083	62.	199.2083	4.0
199.5417	25.00	199.5417	3.6	199.5417	64.	199.5417	10.0
199.8750	30.00	199.8750	3.6	199.8750	50.	199.8750	8.0
200.2083	25.00	200.2083	2.6	200.2083	76.	200.2083	10.0
200.5417	27.20	200.5417	3.1	200.5417	69.	200.5417	3.0
200.8750	26.10	200.8750	6.7	200.8750	72.	200.8750	10.0
201.2083	24.40	201.2083	3.6	201.2083	74.	201.2083	.0
201.5417	25.60	201.5417	5.7	201.5417	72.	201.5417	6.0
201.8750	32.80	201.8750	5.7	201.8750	41.	201.8750	10.0
202.2083	26.70	202.2083	3.6	202.2083	74.	202.2083	8.0
202.5417	27.80	202.5417	5.1	202.5417	69.	202.5417	10.0
202.8750	32.80	202.8750	5.7	202.8750	49.	202.8750	10.0
203.2083	28.30	203.2083	5.1	203.2083	65.	203.2083	10.0
203.5417	21.70	203.5417	3.1	203.5417	97.	203.5417	10.0
203.8750	27.80	203.8750	4.6	203.8750	65.	203.8750	10.0
204.2083	23.90	204.2083	2.1	204.2083	97.	204.2083	7.0
204.5417	26.70	204.5417	4.1	204.5417	82.	204.5417	10.0
204.8750	33.90	204.8750	7.7	204.8750	52.	204.8750	5.0
205.2083	27.80	205.2083	7.2	205.2083	63.	205.2083	8.0
205.5417	25.00	205.5417	4.1	205.5417	43.	205.5417	3.0
205.8750	28.30	205.8750	6.2	205.8750	32.	205.8750	5.0
206.2083	20.60	206.2083	4.1	206.2083	61.	206.2083	3.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
206.5417	23.30	206.5417	4.6	206.5417	54.	206.5417	3.0
206.8750	28.90	206.8750	7.2	206.8750	30.	206.8750	3.0
207.2083	17.80	207.2083	6.2	207.2083	65.	207.2083	5.0
207.5417	18.90	207.5417	5.7	207.5417	70.	207.5417	3.0
207.8750	19.40	207.8750	6.2	207.8750	59.	207.8750	8.0
208.2083	16.10	208.2083	1.5	208.2083	72.	208.2083	4.0
208.5417	21.10	208.5417	4.1	208.5417	59.	208.5417	.0
208.8750	21.10	208.8750	5.1	208.8750	55.	208.8750	5.0
209.2083	16.10	209.2083	2.6	209.2083	78.	209.2083	.0
209.5417	20.60	209.5417	4.1	209.5417	59.	209.5417	4.0
209.8750	22.80	209.8750	5.1	209.8750	46.	209.8750	7.0
210.2083	21.10	210.2083	7.2	210.2083	61.	210.2083	10.0
210.5417	22.20	210.5417	5.1	210.5417	66.	210.5417	10.0
210.8750	21.70	210.8750	4.1	210.8750	79.	210.8750	10.0
211.2083	21.10	211.2083	6.7	211.2083	76.	211.2083	10.0
211.5417	19.40	211.5417	7.2	211.5417	90.	211.5417	10.0
211.8750	20.00	211.8750	9.8	211.8750	76.	211.8750	4.0
212.2083	15.60	212.2083	4.1	212.2083	87.	212.2083	.0
212.5417	20.60	212.5417	5.1	212.5417	63.	212.5417	3.0
212.8750	22.80	212.8750	4.6	212.8750	60.	212.8750	5.0
213.2083	17.20	213.2083	4.6	213.2083	84.	213.2083	.0
213.5417	22.80	213.5417	6.7	213.5417	62.	213.5417	1.0
213.8750	32.20	213.8750	10.3	213.8750	44.	213.8750	4.0

Influent Flowrate data		Influent Temperature data		Diffused Air Flowrate data		Substrate Removal Rate	
DateTime	Influent Flow	DateTime	Influent Temp.	DateTime	Air Flowrate	DateTime	Sub. Removal
183.7083	295230.	183.7083	17.2	183.7083	23.	183.7083	23028.
184.7083	363360.	184.7083	17.8	184.7083	20.	184.7083	14171.
185.7083	287660.	185.7083	17.8	185.7083	19.	185.7083	16972.
186.7083	261165.	186.7083	17.2	186.7083	20.	186.7083	12014.
187.7083	253595.	187.7083	17.2	187.7083	20.	187.7083	13694.
188.7083	249810.	188.7083	17.2	188.7083	20.	188.7083	15238.
189.7083	295230.	189.7083	17.8	189.7083	19.	189.7083	12990.
190.7083	306585.	190.7083	17.8	190.7083	19.	190.7083	13183.
191.7083	268735.	191.7083	17.8	191.7083	20.	191.7083	16930.
192.7083	264950.	192.7083	17.8	192.7083	19.	192.7083	19606.
193.7083	268735.	193.7083	17.8	193.7083	19.	193.7083	19349.
194.7083	355790.	194.7083	18.3	194.7083	20.	194.7083	28107.
195.7083	306585.	195.7083	17.8	195.7083	20.	195.7083	17782.
196.7083	261165.	196.7083	17.8	196.7083	19.	196.7083	15670.
197.7083	268735.	197.7083	17.8	197.7083	20.	197.7083	17468.
198.7083	268735.	198.7083	18.3	198.7083	22.	198.7083	51328.
199.7083	268735.	199.7083	18.3	199.7083	19.	199.7083	46491.
200.7083	268735.	200.7083	18.3	200.7083	18.	200.7083	36817.
201.7083	272520.	201.7083	18.9	201.7083	21.	201.7083	29160.
202.7083	257380.	202.7083	18.3	202.7083	22.	202.7083	24194.
203.7083	325510.	203.7083	18.3	203.7083	20.	203.7083	31574.
204.7083	306585.	204.7083	18.3	204.7083	20.	204.7083	23300.
205.7083	310370.	205.7083	18.9	205.7083	23.	205.7083	120424.
206.7083	280090.	206.7083	18.3	206.7083	23.	206.7083	214829.
207.7083	264950.	207.7083	18.3	207.7083	22.	207.7083	101211.
208.7083	264950.	208.7083	18.3	208.7083	24.	208.7083	30999.
209.7083	249810.	209.7083	18.3	209.7083	25.	209.7083	41718.
210.7083	234670.	210.7083	18.3	210.7083	22.	210.7083	26752.
211.7083	280090.	211.7083	18.3	211.7083	22.	211.7083	84027.
212.7083	272520.	212.7083	18.9	212.7083	23.	212.7083	34883.
213.7083	261165.	213.7083	18.9	213.7083	22.	213.7083	39958.

Spray Area data

DateTime	Spray Area
183.7083	.0
213.7083	.0

Number of Aerators data

DateTime	Number of Aerators
183.7083	.0
213.7083	.0

Solar Radiation Data

DateTime	Solar Radiation
183.2083	0.
213.2083	0.

Chino - January Input Files

Latitude	34.03
Longitude	117.6
Ground Temperature	20
Basin Surface Area	2898
Basin Volume	15728
Submerged Wall Area Exposed to Air	481
Heat Transfer Coefficient to Air	50000
Submerged Wall Area Exposed to Ground	688
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	750
Efficiency of Aerator	60
Power Input to Compressor	0
Efficiency of Compressor	0
Cell Yield	0.27
Start Date	1.8333
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	20

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
1.3333	12.80	1.3333	2.1	1.3333	57.	1.3333	.0
1.6667	11.10	1.6667	4.1	1.6667	57.	1.6667	2.0
2.0000	19.40	2.0000	4.1	2.0000	36.	2.0000	10.0
2.3333	15.60	2.3333	3.1	2.3333	35.	2.3333	10.0
2.6667	15.60	2.6667	5.1	2.6667	30.	2.6667	10.0
3.0000	20.60	3.0000	4.6	3.0000	25.	3.0000	10.0
3.3333	15.60	3.3333	5.7	3.3333	46.	3.3333	10.0
3.6667	11.10	3.6667	6.2	3.6667	90.	3.6667	10.0
4.0000	12.80	4.0000	4.6	4.0000	83.	4.0000	10.0
4.3333	12.80	4.3333	2.6	4.3333	80.	4.3333	9.0
4.6667	12.80	4.6667	2.1	4.6667	77.	4.6667	10.0
5.0000	16.70	5.0000	3.1	5.0000	78.	5.0000	9.0
5.3333	15.00	5.3333	4.6	5.3333	90.	5.3333	10.0
5.6667	14.40	5.6667	3.6	5.6667	93.	5.6667	10.0
6.0000	11.70	6.0000	2.6	6.0000	77.	6.0000	9.0
6.3333	10.00	6.3333	2.6	6.3333	93.	6.3333	10.0
6.6667	8.30	6.6667	1.5	6.6667	93.	6.6667	.0
7.0000	13.30	7.0000	9.3	7.0000	72.	7.0000	2.0
7.3333	10.00	7.3333	2.1	7.3333	80.	7.3333	.0
7.6667	9.40	7.6667	3.6	7.6667	86.	7.6667	10.0
8.0000	9.40	8.0000	8.2	8.0000	90.	8.0000	10.0
8.3333	9.40	8.3333	4.1	8.3333	77.	8.3333	1.0
8.6667	7.20	8.6667	2.1	8.6667	86.	8.6667	.0
9.0000	15.60	9.0000	3.6	9.0000	58.	9.0000	.0
9.3333	9.40	9.3333	4.1	9.3333	80.	9.3333	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
9.6667	10.00	9.6667	.0	9.6667	52.	9.6667	.0
10.0000	17.80	10.0000	3.6	10.0000	43.	10.0000	.0
10.3333	11.70	10.3333	.0	10.3333	47.	10.3333	.0
10.6667	15.00	10.6667	5.1	10.6667	25.	10.6667	1.0
11.0000	18.90	11.0000	1.5	11.0000	49.	11.0000	9.0
11.3333	15.60	11.3333	1.5	11.3333	29.	11.3333	2.0
11.6667	12.80	11.6667	3.1	11.6667	36.	11.6667	.0
12.0000	16.10	12.0000	4.6	12.0000	70.	12.0000	.0
12.3333	13.90	12.3333	6.2	12.3333	20.	12.3333	.0
12.6667	12.20	12.6667	1.5	12.6667	21.	12.6667	.0
13.0000	16.70	13.0000	4.1	13.0000	40.	13.0000	5.0
13.3333	10.60	13.3333	1.5	13.3333	52.	13.3333	4.0
13.6667	10.60	13.6667	1.5	13.6667	35.	13.6667	.0
14.0000	15.60	14.0000	5.1	14.0000	34.	14.0000	.0
14.3333	10.00	14.3333	2.6	14.3333	48.	14.3333	.0
14.6667	8.90	14.6667	2.1	14.6667	52.	14.6667	.0
15.0000	16.10	15.0000	4.1	15.0000	38.	15.0000	.0
15.3333	11.70	15.3333	1.5	15.3333	53.	15.3333	.0
15.6667	11.10	15.6667	2.6	15.6667	47.	15.6667	.0
16.0000	20.00	16.0000	3.1	16.0000	33.	16.0000	1.0
16.3333	13.30	16.3333	3.1	16.3333	37.	16.3333	1.0
16.6667	12.80	16.6667	4.1	16.6667	30.	16.6667	3.0
17.0000	18.30	17.0000	4.6	17.0000	32.	17.0000	.0
17.3333	13.30	17.3333	3.1	17.3333	44.	17.3333	3.0
17.6667	11.70	17.6667	2.6	17.6667	35.	17.6667	10.0
18.0000	16.70	18.0000	2.1	18.0000	70.	18.0000	.0
18.3333	9.40	18.3333	3.1	18.3333	100.	18.3333	7.0
18.6667	9.40	18.6667	3.6	18.6667	86.	18.6667	10.0
19.0000	16.10	19.0000	4.1	19.0000	67.	19.0000	10.0
19.3333	11.10	19.3333	.0	19.3333	80.	19.3333	.0
19.6667	12.20	19.6667	2.1	19.6667	40.	19.6667	1.0
20.0000	21.70	20.0000	3.1	20.0000	18.	20.0000	.0
20.3333	13.30	20.3333	.0	20.3333	33.	20.3333	.0
20.6667	11.70	20.6667	3.1	20.6667	37.	20.6667	.0
21.0000	17.20	21.0000	7.2	21.0000	38.	21.0000	.0
21.3333	12.20	21.3333	2.1	21.3333	72.	21.3333	.0
21.6667	11.70	21.6667	3.6	21.6667	53.	21.6667	.0
22.0000	15.60	22.0000	4.1	22.0000	70.	22.0000	.0
22.3333	10.60	22.3333	2.1	22.3333	96.	22.3333	.0
22.6667	11.70	22.6667	2.1	22.6667	77.	22.6667	.0
23.0000	16.10	23.0000	4.1	23.0000	67.	23.0000	.0
23.3333	12.20	23.3333	.0	23.3333	90.	23.3333	.0
23.6667	12.80	23.6667	.0	23.6667	34.	23.6667	.0
24.0000	18.90	24.0000	4.1	24.0000	39.	24.0000	.0
24.3333	13.30	24.3333	1.5	24.3333	60.	24.3333	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
24.6667	13.90	24.6667	.0	24.6667	26.	24.6667	.0
25.0000	19.40	25.0000	4.6	25.0000	35.	25.0000	.0
25.3333	11.70	25.3333	.0	25.3333	74.	25.3333	1.0
25.6667	11.70	25.6667	2.6	25.6667	47.	25.6667	10.0
26.0000	16.70	26.0000	4.1	26.0000	70.	26.0000	8.0
26.3333	11.70	26.3333	.0	26.3333	90.	26.3333	2.0
26.6667	11.10	26.6667	4.1	26.6667	86.	26.6667	10.0
27.0000	15.00	27.0000	4.6	27.0000	78.	27.0000	10.0
27.3333	11.70	27.3333	.0	27.3333	90.	27.3333	4.0
27.6667	10.60	27.6667	3.1	27.6667	90.	27.6667	.0
28.0000	15.60	28.0000	5.7	28.0000	78.	28.0000	.0
28.3333	12.80	28.3333	2.1	28.3333	97.	28.3333	2.0
28.6667	11.10	28.6667	2.6	28.6667	86.	28.6667	10.0
29.0000	17.80	29.0000	2.1	29.0000	56.	29.0000	9.0
29.3333	13.30	29.3333	.0	29.3333	69.	29.3333	1.0
29.6667	12.20	29.6667	.0	29.6667	57.	29.6667	4.0
30.0000	23.30	30.0000	5.1	30.0000	28.	30.0000	3.0
30.3333	16.10	30.3333	1.5	30.3333	43.	30.3333	.0
30.6667	16.70	30.6667	2.1	30.6667	29.	30.6667	.0
31.0000	20.60	31.0000	5.1	31.0000	49.	31.0000	2.0
31.3333	17.20	31.3333	2.1	31.3333	34.	31.3333	.0
31.6667	15.00	31.6667	.0	31.6667	33.	31.6667	.0
32.0000	18.90	32.0000	5.7	32.0000	43.	32.0000	7.0

Influent Flowrate data

DateTime	Influent Flowrat
1.8333	49584.
2.8333	48070.
3.8333	46556.
4.8333	47691.
5.8333	48070.
6.8333	50341.
7.8333	49584.
8.8333	48070.
9.8333	48070.
10.8333	47691.
11.8333	47691.
12.8333	51098.
13.8333	48070.
14.8333	44285.
15.8333	50341.
16.8333	51098.
17.8333	49584.
18.8333	49584.
19.8333	51855.
20.8333	50719.
21.8333	52612.
22.8333	48827.
23.8333	46934.
24.8333	50719.
25.8333	47691.
26.8333	42771.
27.8333	46934.
28.8333	47691.
29.8333	47691.
30.8333	46556.
31.8333	46556.

Substrate Removal Rate d

DateTime	Substrate Remo
1.8333	12148.
2.8333	12450.
3.8333	13920.
4.8333	11732.
5.8333	12835.
6.8333	14297.
7.8333	11702.
8.8333	10768.
9.8333	10335.
10.8333	10015.
11.8333	10254.
12.8333	16096.
13.8333	12402.
14.8333	10761.
15.8333	14196.
16.8333	11088.
17.8333	11850.
18.8333	10958.
19.8333	12964.
20.8333	12832.
21.8333	-1684.
22.8333	14111.
23.8333	11123.
24.8333	11412.
25.8333	10015.
26.8333	11719.
27.8333	17647.
28.8333	10540.
29.8333	13353.
30.8333	14572.
31.8333	10615.

Influent Temperature data

DateTime	Influent Temperature
1.8333	19.8
31.8333	19.8

Diffused Air Flowrate data

DateTime	Air Flowrate
1.8333	0.
31.8333	0.

Number of Aerators data

DateTime	Number of Aerators
1.8333	6.0
31.8333	6.0

Spray Area data

DateTime	Spray Area
1.8333	12.4
31.8333	12.4

Solar Radiation Data

DateTime	Solar Radiation
1.3333	0.
31.3333	0.

Chino - July Input Files

Latitude	34.03
Longitude	117.6
Ground Temperature	20
Basin Surface Area	2898
Basin Volume	15728
Submerged Wall Area Exposed to Air	481
Heat Transfer Coeficient to Air	50000
Submerged Wall Area Exposed to Ground	688
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	750
Efficiency ofAerator	60
Power Input to Compressor	0
Efficiency of Compressor	0
Cell Yield	0.31
Start Date	183.7917
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	25

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
183.2917	17.80	183.2917	.0	183.2917	84.	183.2917	.0
183.6250	17.20	183.6250	2.1	183.6250	90.	183.6250	10.0
183.9583	21.10	183.9583	5.1	183.9583	68.	183.9583	.0
184.2917	16.70	184.2917	1.5	184.2917	90.	184.2917	10.0
184.6250	17.20	184.6250	2.6	184.6250	87.	184.6250	10.0
184.9583	19.40	184.9583	5.7	184.9583	73.	184.9583	7.0
185.2917	16.70	185.2917	2.6	185.2917	87.	185.2917	10.0
185.6250	18.30	185.6250	1.5	185.6250	81.	185.6250	10.0
185.9583	19.40	185.9583	4.1	185.9583	73.	185.9583	6.0
186.2917	16.70	186.2917	2.6	186.2917	87.	186.2917	10.0
186.6250	17.20	186.6250	.0	186.6250	87.	186.6250	10.0
186.9583	20.00	186.9583	5.1	186.9583	73.	186.9583	9.0
187.2917	17.20	187.2917	2.1	187.2917	90.	187.2917	10.0
187.6250	20.60	187.6250	3.6	187.6250	73.	187.6250	4.0
187.9583	21.70	187.9583	4.6	187.9583	68.	187.9583	.0
188.2917	18.90	188.2917	2.6	188.2917	84.	188.2917	1.0
188.6250	20.60	188.6250	2.1	188.6250	73.	188.6250	5.0
188.9583	22.20	188.9583	4.6	188.9583	69.	188.9583	4.0
189.2917	18.30	189.2917	.0	189.2917	84.	189.2917	7.0
189.6250	18.90	189.6250	3.1	189.6250	84.	189.6250	8.0
189.9583	22.20	189.9583	7.2	189.9583	69.	189.9583	4.0
190.2917	18.30	190.2917	1.5	190.2917	84.	190.2917	9.0
190.6250	18.30	190.6250	3.6	190.6250	90.	190.6250	10.0
190.9583	20.60	190.9583	6.2	190.9583	76.	190.9583	6.0
191.2917	17.20	191.2917	3.1	191.2917	87.	191.2917	8.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
191.6250	18.30	191.6250	2.6	191.6250	76.	191.6250	10.0
191.9583	20.60	191.9583	5.7	191.9583	63.	191.9583	.0
192.2917	17.20	192.2917	2.6	192.2917	87.	192.2917	10.0
192.6250	17.80	192.6250	3.1	192.6250	84.	192.6250	10.0
192.9583	20.60	192.9583	6.2	192.9583	79.	192.9583	2.0
193.2917	17.80	193.2917	1.5	193.2917	84.	193.2917	10.0
193.6250	20.00	193.6250	4.1	193.6250	76.	193.6250	9.0
193.9583	20.60	193.9583	6.7	193.9583	71.	193.9583	.0
194.2917	17.20	194.2917	3.6	194.2917	87.	194.2917	10.0
194.6250	18.30	194.6250	2.6	194.6250	84.	194.6250	10.0
194.9583	20.00	194.9583	6.7	194.9583	73.	194.9583	1.0
195.2917	16.70	195.2917	3.1	195.2917	90.	195.2917	10.0
195.6250	18.30	195.6250	2.6	195.6250	81.	195.6250	10.0
195.9583	20.00	195.9583	6.2	195.9583	73.	195.9583	.0
196.2917	17.80	196.2917	.0	196.2917	84.	196.2917	10.0
196.6250	18.30	196.6250	2.1	196.6250	81.	196.6250	10.0
196.9583	21.10	196.9583	6.2	196.9583	73.	196.9583	1.0
197.2917	18.30	197.2917	2.6	197.2917	84.	197.2917	10.0
197.6250	19.40	197.6250	2.1	197.6250	70.	197.6250	10.0
197.9583	20.60	197.9583	5.1	197.9583	68.	197.9583	.0
198.2917	17.80	198.2917	3.6	198.2917	84.	198.2917	8.0
198.6250	20.00	198.6250	2.6	198.6250	71.	198.6250	5.0
198.9583	20.60	198.9583	7.7	198.9583	68.	198.9583	.0
199.2917	17.20	199.2917	2.1	199.2917	84.	199.2917	10.0
199.6250	18.90	199.6250	2.6	199.6250	76.	199.6250	10.0
199.9583	20.00	199.9583	7.2	199.9583	71.	199.9583	1.0
200.2917	17.80	200.2917	2.1	200.2917	81.	200.2917	10.0
200.6250	18.30	200.6250	3.1	200.6250	78.	200.6250	10.0
200.9583	20.00	200.9583	5.1	200.9583	68.	200.9583	10.0
201.2917	17.80	201.2917	4.1	201.2917	87.	201.2917	4.0
201.6250	16.70	201.6250	4.1	201.6250	93.	201.6250	10.0
201.9583	20.00	201.9583	6.2	201.9583	71.	201.9583	2.0
202.2917	16.70	202.2917	4.1	202.2917	81.	202.2917	2.0
202.6250	18.30	202.6250	2.1	202.6250	76.	202.6250	10.0
202.9583	20.60	202.9583	6.7	202.9583	66.	202.9583	1.0
203.2917	16.70	203.2917	3.1	203.2917	87.	203.2917	.0
203.6250	18.30	203.6250	4.6	203.6250	76.	203.6250	7.0
203.9583	20.00	203.9583	8.7	203.9583	71.	203.9583	7.0
204.2917	17.20	204.2917	3.1	204.2917	84.	204.2917	10.0
204.6250	17.20	204.6250	3.1	204.6250	84.	204.6250	10.0
204.9583	18.90	204.9583	6.2	204.9583	78.	204.9583	9.0
205.2917	17.80	205.2917	3.1	205.2917	84.	205.2917	10.0
205.6250	18.30	205.6250	3.1	205.6250	81.	205.6250	10.0
205.9583	20.00	205.9583	6.7	205.9583	71.	205.9583	2.0
206.2917	18.30	206.2917	2.1	206.2917	78.	206.2917	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
206.6250	19.40	206.6250	1.5	206.6250	73.	206.6250	10.0
206.9583	21.70	206.9583	5.7	206.9583	68.	206.9583	1.0
207.2917	18.90	207.2917	2.1	207.2917	81.	207.2917	10.0
207.6250	18.90	207.6250	4.6	207.6250	76.	207.6250	10.0
207.9583	20.60	207.9583	6.7	207.9583	73.	207.9583	3.0
208.2917	18.30	208.2917	3.1	208.2917	81.	208.2917	10.0
208.6250	19.40	208.6250	2.6	208.6250	76.	208.6250	10.0
208.9583	20.60	208.9583	6.7	208.9583	68.	208.9583	1.0
209.2917	16.70	209.2917	4.1	209.2917	84.	209.2917	10.0
209.6250	18.30	209.6250	3.1	209.6250	81.	209.6250	10.0
209.9583	21.10	209.9583	8.2	209.9583	68.	209.9583	.0
210.2917	17.80	210.2917	3.1	210.2917	87.	210.2917	9.0
210.6250	18.30	210.6250	2.6	210.6250	81.	210.6250	3.0
210.9583	20.60	210.9583	6.2	210.9583	73.	210.9583	2.0
211.2917	17.20	211.2917	3.1	211.2917	90.	211.2917	.0
211.6250	19.40	211.6250	2.6	211.6250	78.	211.6250	9.0
211.9583	20.00	211.9583	6.7	211.9583	76.	211.9583	6.0
212.2917	17.80	212.2917	3.6	212.2917	87.	212.2917	10.0
212.6250	18.30	212.6250	4.1	212.6250	81.	212.6250	10.0
212.9583	21.10	212.9583	6.2	212.9583	71.	212.9583	5.0
213.2917	18.90	213.2917	2.1	213.2917	81.	213.2917	9.0
213.6250	19.40	213.6250	3.1	213.6250	81.	213.6250	9.0
213.9583	21.10	213.9583	6.2	213.9583	73.	213.9583	9.0

Influent Flowrate data

DateTime	Influent Flowrate
183.7917	40500.
184.7917	43528.
185.7917	41635.
186.7917	43906.
187.7917	42392.
188.7917	43528.
189.7917	45799.
190.7917	45420.
191.7917	45420.
192.7917	45042.
193.7917	46177.
194.7917	43906.
195.7917	45420.
196.7917	45042.
197.7917	44285.
198.7917	44285.
199.7917	45420.
200.7917	45042.
201.7917	44285.
202.7917	45799.
203.7917	43906.
204.7917	43528.
205.7917	45420.
206.7917	46177.
207.7917	43149.
208.7917	45420.
209.7917	45799.
210.7917	45042.
211.7917	44663.
212.7917	45042.
213.7917	51098.

Substrate Removal Rate d

DateTime	Substrate Remo
183.7917	13689.
184.7917	11317.
185.7917	9201.
186.7917	8562.
187.7917	5765.
188.7917	7661.
189.7917	8061.
190.7917	8176.
191.7917	8357.
192.7917	8738.
193.7917	8220.
194.7917	7727.
195.7917	9039.
196.7917	7702.
197.7917	7086.
198.7917	5934.
199.7917	8266.
200.7917	7252.
201.7917	9344.
202.7917	7236.
203.7917	7332.
204.7917	8793.
205.7917	8312.
206.7917	8727.
207.7917	6861.
208.7917	6404.
209.7917	7007.
210.7917	8468.
211.7917	7816.
212.7917	8603.
213.7917	9555.

Influent Temperature data

DateTime	Influent Temperature
183.7917	27.4
213.7917	27.4

Diffused Air Flowrate data

DateTime	Air Flowrate
183.7917	0.
213.7917	0.

Number of Aerators data

DateTime	Number of Aerators
183.7917	6.0
213.7917	6.0

Spray Area data

DateTime	Spray Area
183.7917	12.4
213.7917	12.4

Solar Radiation Data

DateTime	Solar Radiation
183.2917	0.
213.2917	0.

Sacramento - January Input Files

Latitude	38.5
Longitude	121.5
Ground Temperature	12
Basin Surface Area	6310
Basin Volume	57417
Submerged Wall Area Exposed to Air	0
Heat Transfer Coeficient to Air	0
Submerged Wall Area Exposed to Grounc	3189
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	215
Efficiency' of Aerator	75
Power Input to Compressor	947
Efficiency of Compressor	100
Cell Yield	0.48
Start Date	1.8333
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	21

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
1.3333	5.60	1.3333	.0	1.3333	100.	1.3333	.0
1.6667	3.30	1.6667	3.1	1.6667	89.	1.6667	.0
2.0000	13.30	2.0000	2.1	2.0000	57.	2.0000	.0
2.3333	3.30	2.3333	.0	2.3333	96.	2.3333	.0
2.6667	.60	2.6667	.0	2.6667	100.	2.6667	.0
3.0000	11.70	3.0000	3.6	3.0000	66.	3.0000	8.0
3.3333	4.40	3.3333	3.6	3.3333	96.	3.3333	10.0
3.6667	4.40	3.6667	2.1	3.6667	100.	3.6667	10.0
4.0000	11.70	4.0000	3.6	4.0000	74.	4.0000	8.0
4.3333	9.40	4.3333	4.1	4.3333	93.	4.3333	10.0
4.6667	8.90	4.6667	3.1	4.6667	93.	4.6667	7.0
5.0000	13.90	5.0000	4.6	5.0000	69.	5.0000	10.0
5.3333	11.10	5.3333	11.3	5.3333	93.	5.3333	10.0
5.6667	7.80	5.6667	4.6	5.6667	93.	5.6667	10.0
6.0000	10.60	6.0000	5.1	6.0000	83.	6.0000	5.0
6.3333	7.80	6.3333	4.1	6.3333	93.	6.3333	10.0
6.6667	7.80	6.6667	5.7	6.6667	96.	6.6667	10.0
7.0000	9.40	7.0000	3.6	7.0000	96.	7.0000	10.0
7.3333	8.30	7.3333	3.1	7.3333	100.	7.3333	10.0
7.6667	7.80	7.6667	6.7	7.6667	93.	7.6667	10.0
8.0000	10.60	8.0000	7.2	8.0000	74.	8.0000	.0
8.3333	5.00	8.3333	2.6	8.3333	93.	8.3333	.0
8.6667	5.00	8.6667	.0	8.6667	100.	8.6667	10.0
9.0000	10.00	9.0000	1.5	9.0000	83.	9.0000	3.0
9.3333	2.80	9.3333	2.1	9.3333	100.	9.3333	8.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
9.6667	.60	9.6667	2.1	9.6667	100.	9.6667	7.0
10.0000	7.20	10.0000	3.6	10.0000	54.	10.0000	1.0
10.3333	3.90	10.3333	2.1	10.3333	100.	10.3333	10.0
10.6667	3.30	10.6667	1.5	10.6667	100.	10.6667	10.0
11.0000	5.60	11.0000	1.5	11.0000	93.	11.0000	10.0
11.3333	5.00	11.3333	2.6	11.3333	96.	11.3333	10.0
11.6667	3.90	11.6667	4.1	11.6667	96.	11.6667	10.0
12.0000	12.80	12.0000	8.2	12.0000	49.	12.0000	.0
12.3333	6.10	12.3333	6.2	12.3333	65.	12.3333	.0
12.6667	.00	12.6667	1.5	12.6667	96.	12.6667	.0
13.0000	10.00	13.0000	4.1	13.0000	61.	13.0000	9.0
13.3333	2.20	13.3333	.0	13.3333	93.	13.3333	.0
13.6667	.00	13.6667	2.6	13.6667	100.	13.6667	3.0
14.0000	10.00	14.0000	3.6	14.0000	64.	14.0000	7.0
14.3333	2.80	14.3333	.0	14.3333	100.	14.3333	.0
14.6667	-1.10	14.6667	.0	14.6667	100.	14.6667	7.0
15.0000	11.70	15.0000	2.1	15.0000	62.	15.0000	5.0
15.3333	3.90	15.3333	3.1	15.3333	100.	15.3333	3.0
15.6667	3.90	15.6667	2.6	15.6667	100.	15.6667	10.0
16.0000	5.60	16.0000	2.6	16.0000	96.	16.0000	10.0
16.3333	5.60	16.3333	2.6	16.3333	96.	16.3333	10.0
16.6667	3.90	16.6667	1.5	16.6667	100.	16.6667	10.0
17.0000	5.60	17.0000	3.1	17.0000	93.	17.0000	10.0
17.3333	4.40	17.3333	3.1	17.3333	96.	17.3333	10.0
17.6667	3.90	17.6667	2.6	17.6667	100.	17.6667	10.0
18.0000	6.10	18.0000	1.5	18.0000	93.	18.0000	10.0
18.3333	6.10	18.3333	.0	18.3333	93.	18.3333	10.0
18.6667	2.20	18.6667	.0	18.6667	100.	18.6667	5.0
19.0000	8.30	19.0000	5.7	19.0000	80.	19.0000	1.0
19.3333	3.30	19.3333	2.6	19.3333	100.	19.3333	10.0
19.6667	2.80	19.6667	2.1	19.6667	100.	19.6667	10.0
20.0000	6.10	20.0000	1.5	20.0000	86.	20.0000	10.0
20.3333	3.30	20.3333	2.1	20.3333	100.	20.3333	10.0
20.6667	2.80	20.6667	3.6	20.6667	100.	20.6667	10.0
21.0000	5.60	21.0000	2.1	21.0000	83.	21.0000	7.0
21.3333	3.90	21.3333	2.1	21.3333	96.	21.3333	10.0
21.6667	3.30	21.6667	1.5	21.6667	100.	21.6667	10.0
22.0000	6.70	22.0000	.0	22.0000	83.	22.0000	2.0
22.3333	2.80	22.3333	2.1	22.3333	96.	22.3333	10.0
22.6667	2.80	22.6667	.0	22.6667	100.	22.6667	10.0
23.0000	4.40	23.0000	2.1	23.0000	89.	23.0000	10.0
23.3333	3.30	23.3333	2.1	23.3333	93.	23.3333	10.0
23.6667	1.70	23.6667	2.1	23.6667	100.	23.6667	10.0
24.0000	3.90	24.0000	1.5	24.0000	89.	24.0000	10.0
24.3333	2.80	24.3333	.0	24.3333	93.	24.3333	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
24.6667	1.70	24.6667	3.6	24.6667	100.	24.6667	10.0
25.0000	4.40	25.0000	3.6	25.0000	82.	25.0000	10.0
25.3333	2.20	25.3333	3.6	25.3333	96.	25.3333	10.0
25.6667	3.90	25.6667	3.1	25.6667	96.	25.6667	10.0
26.0000	9.40	26.0000	5.7	26.0000	83.	26.0000	10.0
26.3333	4.40	26.3333	2.1	26.3333	100.	26.3333	10.0
26.6667	5.60	26.6667	2.1	26.6667	100.	26.6667	10.0
27.0000	12.80	27.0000	3.1	27.0000	75.	27.0000	.0
27.3333	7.20	27.3333	.0	27.3333	100.	27.3333	10.0
27.6667	6.70	27.6667	3.1	27.6667	96.	27.6667	10.0
28.0000	10.00	28.0000	.0	28.0000	74.	28.0000	8.0
28.3333	7.20	28.3333	1.5	28.3333	93.	28.3333	10.0
28.6667	7.80	28.6667	3.1	28.6667	100.	28.6667	10.0
29.0000	11.10	29.0000	9.3	29.0000	90.	29.0000	10.0
29.3333	7.20	29.3333	5.1	29.3333	96.	29.3333	.0
29.6667	6.10	29.6667	3.6	29.6667	100.	29.6667	10.0
30.0000	10.00	30.0000	1.0	30.0000	86.	30.0000	10.0
30.3333	5.00	30.3333	2.6	30.3333	100.	30.3333	3.0
30.6667	4.40	30.6667	4.1	30.6667	100.	30.6667	10.0
31.0000	10.60	31.0000	3.6	31.0000	80.	31.0000	9.0
31.3333	8.30	31.3333	.0	31.3333	100.	31.3333	10.0
31.6667	7.80	31.6667	2.6	31.6667	100.	31.6667	10.0
32.0000	11.10	32.0000	.0	32.0000	80.	32.0000	10.0

Influent Flowrate data		Influent Temperature datc		Diffused Air Flowrate datc		Substrate Removal data	
DateTime	Influent Flow	DateTime	Influent Temp.	DateTime	Air Flowrate	DateTime	Sub. Removal
1.8333	488644.	1.8333	19.5	1.8333	.3610	1.8333	128551.
2.8333	515517.	2.8333	19.8	2.8333	.3350	2.8333	134034.
3.8333	563208.	3.8333	20.0	3.8333	.3500	3.8333	136903.
4.8333	596516.	4.8333	19.8	4.8333	.3620	4.8333	133987.
5.8333	784252.	5.8333	17.6	5.8333	.4000	5.8333	155644.
6.8333	692655.	6.8333	18.8	6.8333	.4080	6.8333	172631.
7.8333	668431.	7.8333	18.7	7.8333	.4380	7.8333	144998.
8.8333	615820.	8.8333	20.3	8.8333	.4550	8.8333	144007.
9.8333	597652.	9.8333	19.6	9.8333	.4500	9.8333	148953.
10.8333	581376.	10.8333	20.2	10.8333	.4200	10.8333	137741.
11.8333	518545.	11.8333	19.7	11.8333	.3920	11.8333	138013.
12.8333	510975.	12.8333	19.4	12.8333	.3910	12.8333	110056.
13.8333	535578.	13.8333	19.6	13.8333	.4510	13.8333	135130.
14.8333	533307.	14.8333	19.9	14.8333	.4500	14.8333	107482.
15.8333	575320.	15.8333	19.4	15.8333	.4020	15.8333	132766.
16.8333	586675.	16.8333	19.7	16.8333	.3900	16.8333	145315.
17.8333	586297.	17.8333	19.6	17.8333	.5090	17.8333	156045.
18.8333	615441.	18.8333	19.3	18.8333	.4050	18.8333	172323.
19.8333	606357.	19.8333	18.9	19.8333	.3720	19.8333	124070.
20.8333	598409.	20.8333	19.1	20.8333	.4380	20.8333	150983.
21.8333	601815.	21.8333	19.3	21.8333	.4050	21.8333	141658.
22.8333	652534.	22.8333	19.1	22.8333	.4410	22.8333	134522.
23.8333	607114.	23.8333	19.1	23.8333	.4260	23.8333	181200.
24.8333	704767.	24.8333	18.7	24.8333	.4380	24.8333	145290.
25.8333	611278.	25.8333	18.5	25.8333	.4090	25.8333	126958.
26.8333	569264.	26.8333	18.7	26.8333	.3850	26.8333	126990.
27.8333	576456.	27.8333	18.9	27.8333	.3840	27.8333	110857.
28.8333	666539.	28.8333	18.4	28.8333	.4150	28.8333	146638.
29.8333	633231.	29.8333	18.9	29.8333	.3890	29.8333	138337.
30.8333	546933.	30.8333	18.6	30.8333	.3780	30.8333	96765.
31.8333	625282.	31.8333	19.5	31.8333	.3860	31.8333	100045.

Number of Aerators data		Spray Area data		Solar Radiation Data	
DateTime	No. Aerators	DateTime	Spray Area	DateTime	Solar Radiation
1.8333	.0	1.8333	.0	1.3333	0.
31.8333	.0	31.8333	.0	31.3333	0.

Sacramento - July Input Files

Latitude	38.5
Longitude	121.5
Ground Temperature	22
Basin Surface Area	6565
Basin Volume	59744
Submerged Wall Area Exposed to Air	0
Heat Transfer Coefiicient to Air	0
Submerged Wall Area Exposed to Grour	3189
Heat Transfer Coefficient to Ground	12000
Power Input to Aerator	215
Efficiency' of Aerator	75
Power Input to Compressor	937
Efficiency of Compressor	100
Cell Yield	0.46
Start Date	183.7917
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	24

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
183.2917	21.10	183.2917	.0	183.2917	66.	183.2917	.0
183.6250	26.70	183.6250	2.6	183.6250	52.	183.6250	.0
183.9583	37.80	183.9583	3.1	183.9583	23.	183.9583	.0
184.2917	24.40	184.2917	.0	184.2917	64.	184.2917	.0
184.6250	28.30	184.6250	2.1	184.6250	49.	184.6250	.0
184.9583	41.10	184.9583	3.1	184.9583	22.	184.9583	.0
185.2917	24.40	185.2917	2.1	185.2917	62.	185.2917	.0
185.6250	27.20	185.6250	.0	185.6250	51.	185.6250	.0
185.9583	43.90	185.9583	4.1	185.9583	21.	185.9583	.0
186.2917	23.30	186.2917	2.6	186.2917	62.	186.2917	.0
186.6250	25.00	186.6250	2.6	186.6250	56.	186.6250	.0
186.9583	42.20	186.9583	5.1	186.9583	23.	186.9583	.0
187.2917	20.60	187.2917	2.6	187.2917	73.	187.2917	.0
187.6250	25.00	187.6250	3.1	187.6250	54.	187.6250	.0
187.9583	37.20	187.9583	5.7	187.9583	21.	187.9583	.0
188.2917	20.60	188.2917	5.7	188.2917	63.	188.2917	.0
188.6250	23.90	188.6250	6.2	188.6250	50.	188.6250	.0
188.9583	32.80	188.9583	7.7	188.9583	31.	188.9583	.0
189.2917	17.80	189.2917	6.2	189.2917	70.	189.2917	.0
189.6250	20.60	189.6250	6.2	189.6250	61.	189.6250	4.0
189.9583	32.20	189.9583	6.2	189.9583	28.	189.9583	1.0
190.2917	15.00	190.2917	4.1	190.2917	84.	190.2917	.0
190.6250	18.30	190.6250	4.1	190.6250	70.	190.6250	.0
190.9583	30.60	190.9583	6.7	190.9583	31.	190.9583	.0
191.2917	13.30	191.2917	4.1	191.2917	90.	191.2917	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
191.6250	17.20	191.6250	4.1	191.6250	73.	191.6250	.0
191.9583	28.30	191.9583	5.1	191.9583	41.	191.9583	.0
192.2917	13.90	192.2917	2.6	192.2917	90.	192.2917	.0
192.6250	18.90	192.6250	2.1	192.6250	68.	192.6250	.0
192.9583	33.90	192.9583	5.1	192.9583	29.	192.9583	.0
193.2917	16.10	193.2917	3.1	193.2917	78.	193.2917	.0
193.6250	19.40	193.6250	2.6	193.6250	66.	193.6250	.0
193.9583	36.70	193.9583	3.1	193.9583	22.	193.9583	.0
194.2917	17.20	194.2917	2.6	194.2917	73.	194.2917	.0
194.6250	20.60	194.6250	4.1	194.6250	66.	194.6250	3.0
194.9583	33.90	194.9583	5.7	194.9583	32.	194.9583	.0
195.2917	16.70	195.2917	4.1	195.2917	84.	195.2917	.0
195.6250	19.40	195.6250	4.6	195.6250	70.	195.6250	3.0
195.9583	32.80	195.9583	6.2	195.9583	34.	195.9583	.0
196.2917	16.70	196.2917	3.6	196.2917	81.	196.2917	2.0
196.6250	18.90	196.6250	5.7	196.6250	70.	196.6250	.0
196.9583	30.00	196.9583	5.1	196.9583	36.	196.9583	.0
197.2917	14.40	197.2917	4.6	197.2917	87.	197.2917	.0
197.6250	17.80	197.6250	6.2	197.6250	70.	197.6250	.0
197.9583	28.90	197.9583	6.2	197.9583	35.	197.9583	.0
198.2917	16.10	198.2917	4.6	198.2917	90.	198.2917	.0
198.6250	19.40	198.6250	6.2	198.6250	76.	198.6250	.0
198.9583	31.10	198.9583	5.7	198.9583	38.	198.9583	2.0
199.2917	17.20	199.2917	2.1	199.2917	84.	199.2917	.0
199.6250	22.20	199.6250	2.6	199.6250	66.	199.6250	.0
199.9583	32.80	199.9583	5.1	199.9583	31.	199.9583	.0
200.2917	17.80	200.2917	4.1	200.2917	70.	200.2917	.0
200.6250	19.40	200.6250	3.6	200.6250	70.	200.6250	.0
200.9583	33.30	200.9583	6.7	200.9583	32.	200.9583	.0
201.2917	17.20	201.2917	4.1	201.2917	81.	201.2917	10.0
201.6250	17.20	201.6250	7.2	201.6250	81.	201.6250	6.0
201.9583	25.00	201.9583	6.7	201.9583	52.	201.9583	9.0
202.2917	15.60	202.2917	5.7	202.2917	84.	202.2917	9.0
202.6250	20.00	202.6250	4.1	202.6250	66.	202.6250	.0
202.9583	27.80	202.9583	7.2	202.9583	41.	202.9583	.0
203.2917	15.60	203.2917	2.6	203.2917	84.	203.2917	4.0
203.6250	18.30	203.6250	2.6	203.6250	73.	203.6250	.0
203.9583	33.90	203.9583	3.6	203.9583	33.	203.9583	1.0
204.2917	17.80	204.2917	2.6	204.2917	81.	204.2917	.0
204.6250	20.60	204.6250	3.1	204.6250	68.	204.6250	.0
204.9583	35.60	204.9583	4.6	204.9583	28.	204.9583	.0
205.2917	18.30	205.2917	3.1	205.2917	73.	205.2917	.0
205.6250	20.60	205.6250	5.7	205.6250	66.	205.6250	.0
205.9583	33.90	205.9583	4.1	205.9583	25.	205.9583	.0
206.2917	15.00	206.2917	3.1	206.2917	93.	206.2917	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
206.6250	18.90	206.6250	4.1	206.6250	73.	206.6250	.0
206.9583	31.70	206.9583	5.1	206.9583	38.	206.9583	.0
207.2917	16.70	207.2917	2.6	207.2917	81.	207.2917	.0
207.6250	18.90	207.6250	2.1	207.6250	70.	207.6250	.0
207.9583	35.60	207.9583	2.1	207.9583	28.	207.9583	.0
208.2917	18.90	208.2917	2.6	208.2917	73.	208.2917	.0
208.6250	21.70	208.6250	.0	208.6250	64.	208.6250	.0
208.9583	35.60	208.9583	8.2	208.9583	30.	208.9583	.0
209.2917	17.80	209.2917	3.1	209.2917	78.	209.2917	.0
209.6250	20.60	209.6250	3.1	209.6250	66.	209.6250	.0
209.9583	33.30	209.9583	5.7	209.9583	37.	209.9583	.0
210.2917	17.20	210.2917	3.6	210.2917	81.	210.2917	.0
210.6250	19.40	210.6250	3.6	210.6250	70.	210.6250	.0
210.9583	35.00	210.9583	5.1	210.9583	32.	210.9583	.0
211.2917	19.40	211.2917	4.1	211.2917	73.	211.2917	.0
211.6250	22.20	211.6250	.0	211.6250	64.	211.6250	.0
211.9583	39.40	211.9583	2.6	211.9583	27.	211.9583	2.0
212.2917	22.80	212.2917	3.1	212.2917	60.	212.2917	5.0
212.6250	22.80	212.6250	.0	212.6250	62.	212.6250	.0
212.9583	40.00	212.9583	7.2	212.9583	27.	212.9583	.0
213.2917	19.40	213.2917	2.6	213.2917	63.	213.2917	.0
213.6250	20.00	213.6250	6.2	213.6250	66.	213.6250	.0
213.9583	30.00	213.9583	7.2	213.9583	37.	213.9583	.0

Influent Flowrate data		Influent Temperature data		Diffused Air Flowrate data		Substrate Removal data	
DateTime	Influent Flow	DateTime	Influent Temp.	DateTime	Air Flowrate	DateTime	Sub. Removal
183.7917	501134.	183.7917	25.1	183.7917	.3600	183.7917	104082.
184.7917	566615.	184.7917	25.9	184.7917	.3650	184.7917	106349.
185.7917	532928.	185.7917	25.8	185.7917	.3720	185.7917	132002.
186.7917	535956.	186.7917	25.7	186.7917	.3810	186.7917	110489.
187.7917	538227.	187.7917	25.8	187.7917	.3660	187.7917	126690.
188.7917	554124.	188.7917	25.9	188.7917	.3730	188.7917	114235.
189.7917	565858.	189.7917	25.8	189.7917	.3530	189.7917	127971.
190.7917	618469.	190.7917	26.1	190.7917	.3890	190.7917	-5709.
191.7917	590082.	191.7917	26.3	191.7917	.4240	191.7917	130726.
192.7917	588568.	192.7917	26.4	192.7917	.4280	192.7917	117714.
193.7917	565479.	193.7917	26.5	193.7917	.4250	193.7917	-7830.
194.7917	550718.	194.7917	26.4	194.7917	.4390	194.7917	121158.
195.7917	551096.	195.7917	26.3	195.7917	.4590	195.7917	105132.
196.7917	495457.	196.7917	26.0	196.7917	.4310	196.7917	87658.
197.7917	546554.	197.7917	26.3	197.7917	.4640	197.7917	112674.
198.7917	574942.	198.7917	26.5	198.7917	.4760	198.7917	107028.
199.7917	607871.	199.7917	26.6	199.7917	.5180	199.7917	122509.
200.7917	607114.	200.7917	26.6	200.7917	.5290	200.7917	132631.
201.7917	627932.	201.7917	26.6	201.7917	.5550	201.7917	166160.
202.7917	593488.	202.7917	26.3	202.7917	.5270	202.7917	138785.
203.7917	578348.	203.7917	26.2	203.7917	.4820	203.7917	129016.
204.7917	603708.	204.7917	26.5	204.7917	.5050	204.7917	134673.
205.7917	619605.	205.7917	26.9	205.7917	.4440	205.7917	247842.
206.7917	727856.	206.7917	27.0	206.7917	.5690	206.7917	200440.
207.7917	568507.	207.7917	26.9	207.7917	.5410	207.7917	131194.
208.7917	606736.	208.7917	27.0	208.7917	.5320	208.7917	140949.
209.7917	668053.	209.7917	27.0	209.7917	.5300	209.7917	195277.
210.7917	667296.	210.7917	26.8	210.7917	.4970	210.7917	180683.
211.7917	638530.	211.7917	27.0	211.7917	.5130	211.7917	147353.
212.7917	608250.	212.7917	27.3	212.7917	.5890	212.7917	154402.
213.7917	656698.	213.7917	27.6	213.7917	.5720		

Number of Aerators data		Spray Area data		Solar Radiation Data	
DateTime	No. Aerators	DateTime	Spray Area	DateTime	Solar Radiation
183.7917	.0	183.7917	.0	183.2917	0.
213.7917	.0	213.7917	.0	213.2917	0.

TITP - January Input Files

Latitude	33.45
Longitude	118.15
Ground Temperature	25.5
Basin Surface Area	6906
Basin Volume	31871
Submerged Wall Area Exposed to Air	0
Heat Transfer Coeficient to Air	0
Submerged Wall Area Exposed to Grounc	10376
Heat Transfer Coefficient to Ground	10196
Power Input to Aerator	0
Efficiency ofAerator	0
Power Input to Compressor	1500
Efficiency of Compressor	75
Cell Yield	0.24
Start Date	1.8333
Model Duration	31
Print Time Interval	0.25
Initial Basin Temperature Estimate	25

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
1.3333	12.80	1.3333	2.1	1.3333	57.	1.3333	.0
1.6667	11.10	1.6667	4.1	1.6667	57.	1.6667	2.0
2.0000	19.40	2.0000	4.1	2.0000	36.	2.0000	10.0
2.3333	15.60	2.3333	3.1	2.3333	35.	2.3333	10.0
2.6667	15.60	2.6667	5.1	2.6667	30.	2.6667	10.0
3.0000	20.60	3.0000	4.6	3.0000	25.	3.0000	10.0
3.3333	15.60	3.3333	5.7	3.3333	46.	3.3333	10.0
3.6667	11.10	3.6667	6.2	3.6667	90.	3.6667	10.0
4.0000	12.80	4.0000	4.6	4.0000	83.	4.0000	10.0
4.3333	12.80	4.3333	2.6	4.3333	80.	4.3333	9.0
4.6667	12.80	4.6667	2.1	4.6667	77.	4.6667	10.0
5.0000	16.70	5.0000	3.1	5.0000	78.	5.0000	9.0
5.3333	15.00	5.3333	4.6	5.3333	90.	5.3333	10.0
5.6667	14.40	5.6667	3.6	5.6667	93.	5.6667	10.0
6.0000	11.70	6.0000	2.6	6.0000	77.	6.0000	9.0
6.3333	10.00	6.3333	2.6	6.3333	93.	6.3333	10.0
6.6667	8.30	6.6667	1.5	6.6667	93.	6.6667	.0
7.0000	13.30	7.0000	9.3	7.0000	72.	7.0000	2.0
7.3333	10.00	7.3333	2.1	7.3333	80.	7.3333	.0
7.6667	9.40	7.6667	3.6	7.6667	86.	7.6667	10.0
8.0000	9.40	8.0000	8.2	8.0000	90.	8.0000	10.0
8.3333	9.40	8.3333	4.1	8.3333	77.	8.3333	1.0
8.6667	7.20	8.6667	2.1	8.6667	86.	8.6667	.0
9.0000	15.60	9.0000	3.6	9.0000	58.	9.0000	.0
9.3333	9.40	9.3333	4.1	9.3333	80.	9.3333	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
9.6667	10.00	9.6667	.0	9.6667	52.	9.6667	.0
10.0000	17.80	10.0000	3.6	10.0000	43.	10.0000	.0
10.3333	11.70	10.3333	.0	10.3333	47.	10.3333	.0
10.6667	15.00	10.6667	5.1	10.6667	25.	10.6667	1.0
11.0000	18.90	11.0000	1.5	11.0000	49.	11.0000	9.0
11.3333	15.60	11.3333	1.5	11.3333	29.	11.3333	2.0
11.6667	12.80	11.6667	3.1	11.6667	36.	11.6667	.0
12.0000	16.10	12.0000	4.6	12.0000	70.	12.0000	.0
12.3333	13.90	12.3333	6.2	12.3333	20.	12.3333	.0
12.6667	12.20	12.6667	1.5	12.6667	21.	12.6667	.0
13.0000	16.70	13.0000	4.1	13.0000	40.	13.0000	5.0
13.3333	10.60	13.3333	1.5	13.3333	52.	13.3333	4.0
13.6667	10.60	13.6667	1.5	13.6667	35.	13.6667	.0
14.0000	15.60	14.0000	5.1	14.0000	34.	14.0000	.0
14.3333	10.00	14.3333	2.6	14.3333	48.	14.3333	.0
14.6667	8.90	14.6667	2.1	14.6667	52.	14.6667	.0
15.0000	16.10	15.0000	4.1	15.0000	38.	15.0000	.0
15.3333	11.70	15.3333	1.5	15.3333	53.	15.3333	.0
15.6667	11.10	15.6667	2.6	15.6667	47.	15.6667	.0
16.0000	20.00	16.0000	3.1	16.0000	33.	16.0000	1.0
16.3333	13.30	16.3333	3.1	16.3333	37.	16.3333	1.0
16.6667	12.80	16.6667	4.1	16.6667	30.	16.6667	3.0
17.0000	18.30	17.0000	4.6	17.0000	32.	17.0000	.0
17.3333	13.30	17.3333	3.1	17.3333	44.	17.3333	3.0
17.6667	11.70	17.6667	2.6	17.6667	35.	17.6667	10.0
18.0000	16.70	18.0000	2.1	18.0000	70.	18.0000	.0
18.3333	9.40	18.3333	3.1	18.3333	100.	18.3333	7.0
18.6667	9.40	18.6667	3.6	18.6667	86.	18.6667	10.0
19.0000	16.10	19.0000	4.1	19.0000	67.	19.0000	10.0
19.3333	11.10	19.3333	.0	19.3333	80.	19.3333	.0
19.6667	12.20	19.6667	2.1	19.6667	40.	19.6667	1.0
20.0000	21.70	20.0000	3.1	20.0000	18.	20.0000	.0
20.3333	13.30	20.3333	.0	20.3333	33.	20.3333	.0
20.6667	11.70	20.6667	3.1	20.6667	37.	20.6667	.0
21.0000	17.20	21.0000	7.2	21.0000	38.	21.0000	.0
21.3333	12.20	21.3333	2.1	21.3333	72.	21.3333	.0
21.6667	11.70	21.6667	3.6	21.6667	53.	21.6667	.0
22.0000	15.60	22.0000	4.1	22.0000	70.	22.0000	.0
22.3333	10.60	22.3333	2.1	22.3333	96.	22.3333	.0
22.6667	11.70	22.6667	2.1	22.6667	77.	22.6667	.0
23.0000	16.10	23.0000	4.1	23.0000	67.	23.0000	.0
23.3333	12.20	23.3333	.0	23.3333	90.	23.3333	.0
23.6667	12.80	23.6667	.0	23.6667	34.	23.6667	.0
24.0000	18.90	24.0000	4.1	24.0000	39.	24.0000	.0
24.3333	13.30	24.3333	1.5	24.3333	60.	24.3333	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
24.6667	13.90	24.6667	.0	24.6667	26.	24.6667	.0
25.0000	19.40	25.0000	4.6	25.0000	35.	25.0000	.0
25.3333	11.70	25.3333	.0	25.3333	74.	25.3333	1.0
25.6667	11.70	25.6667	2.6	25.6667	47.	25.6667	10.0
26.0000	16.70	26.0000	4.1	26.0000	70.	26.0000	8.0
26.3333	11.70	26.3333	.0	26.3333	90.	26.3333	2.0
26.6667	11.10	26.6667	4.1	26.6667	86.	26.6667	10.0
27.0000	15.00	27.0000	4.6	27.0000	78.	27.0000	10.0
27.3333	11.70	27.3333	.0	27.3333	90.	27.3333	4.0
27.6667	10.60	27.6667	3.1	27.6667	90.	27.6667	.0
28.0000	15.60	28.0000	5.7	28.0000	78.	28.0000	.0
28.3333	12.80	28.3333	2.1	28.3333	97.	28.3333	2.0
28.6667	11.10	28.6667	2.6	28.6667	86.	28.6667	10.0
29.0000	17.80	29.0000	2.1	29.0000	56.	29.0000	9.0
29.3333	13.30	29.3333	.0	29.3333	69.	29.3333	1.0
29.6667	12.20	29.6667	.0	29.6667	57.	29.6667	4.0
30.0000	23.30	30.0000	5.1	30.0000	28.	30.0000	3.0
30.3333	16.10	30.3333	1.5	30.3333	43.	30.3333	.0
30.6667	16.70	30.6667	2.1	30.6667	29.	30.6667	.0
31.0000	20.60	31.0000	5.1	31.0000	49.	31.0000	2.0
31.3333	17.20	31.3333	2.1	31.3333	34.	31.3333	.0
31.6667	15.00	31.6667	.0	31.6667	33.	31.6667	.0
32.0000	18.90	32.0000	5.7	32.0000	43.	32.0000	7.0

08.7917
09.7917
10.7917
11.7917

Influent Flowrate data

DateTime	Influent Flowra
1.8333	65102.
2.8333	66238.
3.8333	63967.
4.8333	59046.
5.8333	59425.
6.8333	59803.
7.8333	61696.
8.8333	67373.
9.8333	62074.
10.8333	64724.
11.8333	65859.
12.8333	68887.
13.8333	64345.
14.8333	60182.
15.8333	66238.
16.8333	64724.
17.8333	64724.
18.8333	67752.
19.8333	66616.
20.8333	60939.
21.8333	61317.
22.8333	67373.
23.8333	68509.
24.8333	67373.
25.8333	65481.
26.8333	59803.
27.8333	59803.
28.8333	59046.
29.8333	67752.
30.8333	62074.
31.8333	64724.

Diffused Air Flowrate data

DateTime	Air Flowrate
1.8333	11.
2.8333	10.
3.8333	10.
4.8333	9.
5.8333	10.
6.8333	9.
7.8333	9.
8.8333	9.
9.8333	9.
10.8333	10.
11.8333	10.
12.8333	9.
13.8333	10.
14.8333	10.
15.8333	10.
16.8333	10.
17.8333	10.
18.8333	10.
19.8333	9.
20.8333	9.
21.8333	9.
22.8333	9.
23.8333	10.
24.8333	9.
25.8333	10.
26.8333	9.
27.8333	10.
28.8333	10.
29.8333	9.
30.8333	10.
31.8333	10.

Substrate Removal Rate data

DateTime	Substrate Removal Rate
1.7917	20937.
2.7917	20849.
5.7917	25916.
6.7917	15332.
7.7917	23206.
8.7917	19531.
9.7917	25481.
12.7917	18724.
13.7917	26684.
14.7917	24858.
15.7917	41165.
16.7917	25617.
20.7917	24999.
21.7917	29974.
22.7917	22197.
23.7917	29484.
26.7917	21740.
27.7917	31117.
28.7917	27449.
29.7917	23775.
30.7917	30310.

Spray Area data

DateTime	Spray Area
1.8333	.0
31.8333	.0

Number of Aerators data

DateTime	Number of Aerators
1.8333	.0
31.8333	.0

Influent Temperature data

DateTime	Influent Temperature
1.8333	21.5
31.8333	21.5

Solar Radiation Data

DateTime	Solar Radiation
1.3333	0.
31.3333	0.

TITP - July Input Files

Latitude	33.45
Longitude	118.15
Ground Temperature	25.5
Basin Surface Area	6906
Basin Volume	31871
Submerged Wall Area Exposed to Air	0
Heat Transfer Coefficient to Air	0
Submerged Wall Area Exposed to Groun	10376
Heat Transfer Coefficient to Ground	10196
Power Input to Aerator	0
Efficiency ofAerator	0
Power Input to Compressor	1500
Efficiency of Compressor	75
Cell Yield	0.23
Start Date	183.7917
Model Duration	31
Print Time Interval	0.25
Initial Basin Temperature Estimate	25

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
183.2917	17.80	183.2917	.0	183.2917	84.	183.2917	.0
183.6250	17.20	183.6250	2.1	183.6250	90.	183.6250	10.0
183.9583	21.10	183.9583	5.1	183.9583	68.	183.9583	.0
184.2917	16.70	184.2917	1.5	184.2917	90.	184.2917	10.0
184.6250	17.20	184.6250	2.6	184.6250	87.	184.6250	10.0
184.9583	19.40	184.9583	5.7	184.9583	73.	184.9583	7.0
185.2917	16.70	185.2917	2.6	185.2917	87.	185.2917	10.0
185.6250	18.30	185.6250	1.5	185.6250	81.	185.6250	10.0
185.9583	19.40	185.9583	4.1	185.9583	73.	185.9583	6.0
186.2917	16.70	186.2917	2.6	186.2917	87.	186.2917	10.0
186.6250	17.20	186.6250	.0	186.6250	87.	186.6250	10.0
186.9583	20.00	186.9583	5.1	186.9583	73.	186.9583	9.0
187.2917	17.20	187.2917	2.1	187.2917	90.	187.2917	10.0
187.6250	20.60	187.6250	3.6	187.6250	73.	187.6250	4.0
187.9583	21.70	187.9583	4.6	187.9583	68.	187.9583	.0
188.2917	18.90	188.2917	2.6	188.2917	84.	188.2917	1.0
188.6250	20.60	188.6250	2.1	188.6250	73.	188.6250	5.0
188.9583	22.20	188.9583	4.6	188.9583	69.	188.9583	4.0
189.2917	18.30	189.2917	.0	189.2917	84.	189.2917	7.0
189.6250	18.90	189.6250	3.1	189.6250	84.	189.6250	8.0
189.9583	22.20	189.9583	7.2	189.9583	69.	189.9583	4.0
190.2917	18.30	190.2917	1.5	190.2917	84.	190.2917	9.0
190.6250	18.30	190.6250	3.6	190.6250	90.	190.6250	10.0
190.9583	20.60	190.9583	6.2	190.9583	76.	190.9583	6.0
191.2917	17.20	191.2917	3.1	191.2917	87.	191.2917	8.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
191.6250	18.30	191.6250	2.6	191.6250	76.	191.6250	10.0
191.9583	20.60	191.9583	5.7	191.9583	63.	191.9583	.0
192.2917	17.20	192.2917	2.6	192.2917	87.	192.2917	10.0
192.6250	17.80	192.6250	3.1	192.6250	84.	192.6250	10.0
192.9583	20.60	192.9583	6.2	192.9583	79.	192.9583	2.0
193.2917	17.80	193.2917	1.5	193.2917	84.	193.2917	10.0
193.6250	20.00	193.6250	4.1	193.6250	76.	193.6250	9.0
193.9583	20.60	193.9583	6.7	193.9583	71.	193.9583	.0
194.2917	17.20	194.2917	3.6	194.2917	87.	194.2917	10.0
194.6250	18.30	194.6250	2.6	194.6250	84.	194.6250	10.0
194.9583	20.00	194.9583	6.7	194.9583	73.	194.9583	1.0
195.2917	16.70	195.2917	3.1	195.2917	90.	195.2917	10.0
195.6250	18.30	195.6250	2.6	195.6250	81.	195.6250	10.0
195.9583	20.00	195.9583	6.2	195.9583	73.	195.9583	.0
196.2917	17.80	196.2917	.0	196.2917	84.	196.2917	10.0
196.6250	18.30	196.6250	2.1	196.6250	81.	196.6250	10.0
196.9583	21.10	196.9583	6.2	196.9583	73.	196.9583	1.0
197.2917	18.30	197.2917	2.6	197.2917	84.	197.2917	10.0
197.6250	19.40	197.6250	2.1	197.6250	70.	197.6250	10.0
197.9583	20.60	197.9583	5.1	197.9583	68.	197.9583	.0
198.2917	17.80	198.2917	3.6	198.2917	84.	198.2917	8.0
198.6250	20.00	198.6250	2.6	198.6250	71.	198.6250	5.0
198.9583	20.60	198.9583	7.7	198.9583	68.	198.9583	.0
199.2917	17.20	199.2917	2.1	199.2917	84.	199.2917	10.0
199.6250	18.90	199.6250	2.6	199.6250	76.	199.6250	10.0
199.9583	20.00	199.9583	7.2	199.9583	71.	199.9583	1.0
200.2917	17.80	200.2917	2.1	200.2917	81.	200.2917	10.0
200.6250	18.30	200.6250	3.1	200.6250	78.	200.6250	10.0
200.9583	20.00	200.9583	5.1	200.9583	68.	200.9583	10.0
201.2917	17.80	201.2917	4.1	201.2917	87.	201.2917	4.0
201.6250	16.70	201.6250	4.1	201.6250	93.	201.6250	10.0
201.9583	20.00	201.9583	6.2	201.9583	71.	201.9583	2.0
202.2917	16.70	202.2917	4.1	202.2917	81.	202.2917	2.0
202.6250	18.30	202.6250	2.1	202.6250	76.	202.6250	10.0
202.9583	20.60	202.9583	6.7	202.9583	66.	202.9583	1.0
203.2917	16.70	203.2917	3.1	203.2917	87.	203.2917	.0
203.6250	18.30	203.6250	4.6	203.6250	76.	203.6250	7.0
203.9583	20.00	203.9583	8.7	203.9583	71.	203.9583	7.0
204.2917	17.20	204.2917	3.1	204.2917	84.	204.2917	10.0
204.6250	17.20	204.6250	3.1	204.6250	84.	204.6250	10.0
204.9583	18.90	204.9583	6.2	204.9583	78.	204.9583	9.0
205.2917	17.80	205.2917	3.1	205.2917	84.	205.2917	10.0
205.6250	18.30	205.6250	3.1	205.6250	81.	205.6250	10.0
205.9583	20.00	205.9583	6.7	205.9583	71.	205.9583	2.0
206.2917	18.30	206.2917	2.1	206.2917	78.	206.2917	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
206.6250	19.40	206.6250	1.5	206.6250	73.	206.6250	10.0
206.9583	21.70	206.9583	5.7	206.9583	68.	206.9583	1.0
207.2917	18.90	207.2917	2.1	207.2917	81.	207.2917	10.0
207.6250	18.90	207.6250	4.6	207.6250	76.	207.6250	10.0
207.9583	20.60	207.9583	6.7	207.9583	73.	207.9583	3.0
208.2917	18.30	208.2917	3.1	208.2917	81.	208.2917	10.0
208.6250	19.40	208.6250	2.6	208.6250	76.	208.6250	10.0
208.9583	20.60	208.9583	6.7	208.9583	68.	208.9583	1.0
209.2917	16.70	209.2917	4.1	209.2917	84.	209.2917	10.0
209.6250	18.30	209.6250	3.1	209.6250	81.	209.6250	10.0
209.9583	21.10	209.9583	8.2	209.9583	68.	209.9583	.0
210.2917	17.80	210.2917	3.1	210.2917	87.	210.2917	9.0
210.6250	18.30	210.6250	2.6	210.6250	81.	210.6250	3.0
210.9583	20.60	210.9583	6.2	210.9583	73.	210.9583	2.0
211.2917	17.20	211.2917	3.1	211.2917	90.	211.2917	.0
211.6250	19.40	211.6250	2.6	211.6250	78.	211.6250	9.0
211.9583	20.00	211.9583	6.7	211.9583	76.	211.9583	6.0
212.2917	17.80	212.2917	3.6	212.2917	87.	212.2917	10.0
212.6250	18.30	212.6250	4.1	212.6250	81.	212.6250	10.0
212.9583	21.10	212.9583	6.2	212.9583	71.	212.9583	5.0
213.2917	18.90	213.2917	2.1	213.2917	81.	213.2917	9.0
213.6250	19.40	213.6250	3.1	213.6250	81.	213.6250	9.0
213.9583	21.10	213.9583	6.2	213.9583	73.	213.9583	9.0

Influent Flowrate data

DateTime	Influent Flowrat
183.7917	65102.
184.7917	66238.
185.7917	63967.
186.7917	59046.
187.7917	59425.
188.7917	59803.
189.7917	61696.
190.7917	67373.
191.7917	62074.
192.7917	64724.
193.7917	65859.
194.7917	68887.
195.7917	64345.
196.7917	60182.
197.7917	66238.
198.7917	64724.
199.7917	64724.
200.7917	67752.
201.7917	66616.
202.7917	60939.
203.7917	61317.
204.7917	67373.
205.7917	68509.
206.7917	67373.
207.7917	65481.
208.7917	59803.
209.7917	59803.
210.7917	59046.
211.7917	67752.
212.7917	62074.
213.7917	64724.

Diffused Air Flowrate datc

DateTime	Air Flowrate
183.7917	6.
184.7917	11.
185.7917	12.
186.7917	10.
187.7917	9.
188.7917	10.
189.7917	11.
190.7917	11.
191.7917	11.
192.7917	11.
193.7917	11.
194.7917	10.
195.7917	10.
196.7917	8.
197.7917	10.
198.7917	11.
199.7917	10.
200.7917	11.
201.7917	11.
202.7917	10.
203.7917	10.
204.7917	11.
205.7917	11.
206.7917	11.
207.7917	15.
208.7917	11.
209.7917	10.
210.7917	11.
211.7917	11.
212.7917	10.
213.7917	10.

Substrate Removal Rate data

DateTime	Substrate Removal Rate
183.7917	37238.
184.7917	30800.
186.7917	21729.
189.7917	23876.
190.7917	25130.
191.7917	22471.
192.7917	22977.
193.7917	24104.
196.7917	17513.
197.7917	24442.
198.7917	23818.
199.7917	20000.
200.7917	23849.
203.7917	15084.
204.7917	23176.
205.7917	21032.
206.7917	29779.
207.7917	34508.
210.7917	14525.
211.7917	22900.
212.7917	21540.
213.7917	19223.

Influent Temperature data

DateTime	Influent Temperature
183.7917	27.0
213.7917	27.0

Number of Aerators data

DateTime	Number of Aerators
183.7917	.0
213.7917	.0

Spray Area data

DateTime	Spray Area
183.7917	.0
213.7917	.0

Solar Radiation Data

DateTime	Solar Radiation
183.2917	0.
213.2917	0.

Maine - January Input Files

Latitude	44.55
Longitude	70.5
Ground Temperature	5
Basin Surface Area	8977
Basin Volume	33522
Submerged Wall Area Exposed to Air	0
Heat Transfer Coeflicient to Air	0
Submerged Wall Area Exposed to Groun	8977
Heat Transfer Coefficient to Ground	10000
Power Input to Aerator	0
Efficiency' of Aerator	0
Power Input to Compressor	5000
Efficiency of Compressor	60
Cell Yield	0.24
Start Date	1.7083
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	32

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
1.2083	-6.10	1.2083	2.1	1.2083	68.	1.2083	.0
1.5417	-9.40	1.5417	.0	1.5417	88.	1.5417	.0
1.8750	1.70	1.8750	3.1	1.8750	57.	1.8750	.0
2.2083	-7.20	2.2083	.0	2.2083	92.	2.2083	.0
2.5417	-5.10	2.5417	2.1	2.5417	92.	2.5417	10.0
2.8750	1.70	2.8750	2.1	2.8750	73.	2.8750	10.0
3.2083	-4.40	3.2083	.0	3.2083	96.	3.2083	3.0
3.5417	-1.70	3.5417	3.1	3.5417	82.	3.5417	10.0
3.8750	1.70	3.8750	3.1	3.8750	70.	3.8750	10.0
4.2083	.00	4.2083	2.1	4.2083	75.	4.2083	10.0
4.5417	-1.70	4.5417	5.1	4.5417	72.	4.5417	10.0
4.8750	.60	4.8750	7.7	4.8750	92.	4.8750	10.0
5.2083	1.70	5.2083	4.1	5.2083	96.	5.2083	10.0
5.5417	2.80	5.5417	5.7	5.5417	93.	5.5417	10.0
5.8750	6.10	5.8750	6.2	5.8750	89.	5.8750	10.0
6.2083	3.90	6.2083	3.6	6.2083	76.	6.2083	10.0
6.5417	.00	6.5417	3.1	6.5417	85.	6.5417	.0
6.8750	5.60	6.8750	4.1	6.8750	58.	6.8750	8.0
7.2083	-.60	7.2083	1.5	7.2083	85.	7.2083	4.0
7.5417	-2.20	7.5417	2.1	7.5417	89.	7.5417	10.0
7.8750	3.90	7.8750	4.1	7.8750	55.	7.8750	.0
8.2083	.00	8.2083	4.1	8.2083	69.	8.2083	8.0
8.5417	-3.90	8.5417	6.2	8.5417	55.	8.5417	5.0
8.8750	-.60	8.8750	4.6	8.8750	29.	8.8750	.0
9.2083	-6.70	9.2083	4.6	9.2083	52.	9.2083	2.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
9.5417	-6.70	9.5417	2.6	9.5417	57.	9.5417	10.0
9.8750	-2.20	9.8750	3.1	9.8750	82.	9.8750	10.0
10.2083	-3.30	10.2083	2.6	10.2083	96.	10.2083	10.0
10.5417	-3.90	10.5417	4.1	10.5417	96.	10.5417	5.0
10.8750	.60	10.8750	5.1	10.8750	54.	10.8750	10.0
11.2083	-5.60	11.2083	7.2	11.2083	57.	11.2083	.0
11.5417	-8.90	11.5417	3.1	11.5417	68.	11.5417	.0
11.8750	-6.70	11.8750	8.2	11.8750	30.	11.8750	.0
12.2083	-12.20	12.2083	5.7	12.2083	44.	12.2083	.0
12.5417	-14.40	12.5417	2.1	12.5417	63.	12.5417	.0
12.8750	-4.40	12.8750	4.1	12.8750	42.	12.8750	9.0
13.2083	-4.40	13.2083	2.6	13.2083	46.	13.2083	10.0
13.5417	-2.80	13.5417	2.1	13.5417	58.	13.5417	10.0
13.8750	2.20	13.8750	3.1	13.8750	64.	13.8750	1.0
14.2083	-1.10	14.2083	1.5	14.2083	78.	14.2083	10.0
14.5417	4.40	14.5417	7.2	14.5417	93.	14.5417	10.0
14.8750	8.90	14.8750	8.7	14.8750	100.	14.8750	10.0
15.2083	2.80	15.2083	10.3	15.2083	67.	15.2083	10.0
15.5417	-8.90	15.5417	8.2	15.5417	49.	15.5417	.0
15.8750	-6.70	15.8750	6.7	15.8750	24.	15.8750	.0
16.2083	-13.30	16.2083	3.1	16.2083	48.	16.2083	10.0
16.5417	-15.00	16.5417	4.1	16.5417	52.	16.5417	10.0
16.8750	-12.80	16.8750	5.1	16.8750	32.	16.8750	.0
17.2083	-18.30	17.2083	5.7	17.2083	51.	17.2083	5.0
17.5417	-18.30	17.5417	3.1	17.5417	59.	17.5417	6.0
17.8750	-10.00	17.8750	1.5	17.8750	77.	17.8750	10.0
18.2083	-11.10	18.2083	2.6	18.2083	84.	18.2083	10.0
18.5417	-8.30	18.5417	4.1	18.5417	71.	18.5417	.0
18.8750	-8.30	18.8750	7.7	18.8750	32.	18.8750	6.0
19.2083	-16.10	19.2083	5.7	19.2083	33.	19.2083	.0
19.5417	-17.80	19.5417	1.5	19.5417	48.	19.5417	.0
19.8750	-9.40	19.8750	7.7	19.8750	30.	19.8750	.0
20.2083	-12.20	20.2083	3.6	20.2083	58.	20.2083	.0
20.5417	-11.10	20.5417	2.1	20.5417	61.	20.5417	10.0
20.8750	-7.20	20.8750	3.1	20.8750	62.	20.8750	2.0
21.2083	-12.80	21.2083	2.1	21.2083	70.	21.2083	9.0
21.5417	-12.80	21.5417	1.5	21.5417	67.	21.5417	8.0
21.8750	-3.90	21.8750	6.2	21.8750	44.	21.8750	.0
22.2083	-9.40	22.2083	2.6	22.2083	81.	22.2083	.0
22.5417	-10.00	22.5417	5.7	22.5417	51.	22.5417	.0
22.8750	-5.00	22.8750	1.5	22.8750	19.	22.8750	7.0
23.2083	-10.00	23.2083	.0	23.2083	67.	23.2083	10.0
23.5417	-1.10	23.5417	4.6	23.5417	75.	23.5417	10.0
23.8750	3.90	23.8750	3.1	23.8750	96.	23.8750	10.0
24.2083	9.40	24.2083	13.4	24.2083	93.	24.2083	10.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
24.5417	5.00	24.5417	3.6	24.5417	86.	24.5417	4.0
24.8750	3.90	24.8750	7.7	24.8750	41.	24.8750	3.0
25.2083	-6.10	25.2083	7.7	25.2083	43.	25.2083	9.0
25.5417	-12.80	25.5417	5.7	25.5417	41.	25.5417	.0
25.8750	-8.90	25.8750	4.6	25.8750	29.	25.8750	3.0
26.2083	-13.30	26.2083	3.1	26.2083	41.	26.2083	6.0
26.5417	-13.30	26.5417	3.1	26.5417	55.	26.5417	10.0
26.8750	-6.10	26.8750	5.1	26.8750	33.	26.8750	8.0
27.2083	-12.80	27.2083	3.1	27.2083	50.	27.2083	.0
27.5417	-15.00	27.5417	2.6	27.5417	66.	27.5417	8.0
27.8750	-5.60	27.8750	4.1	27.8750	40.	27.8750	8.0
28.2083	-5.60	28.2083	3.1	28.2083	57.	28.2083	10.0
28.5417	-7.20	28.5417	4.6	28.5417	71.	28.5417	10.0
28.8750	-3.90	28.8750	2.6	28.8750	78.	28.8750	10.0
29.2083	-3.90	29.2083	2.1	29.2083	85.	29.2083	1.0
29.5417	-6.70	29.5417	3.1	29.5417	92.	29.5417	7.0
29.8750	2.80	29.8750	2.1	29.8750	62.	29.8750	.0
30.2083	-2.20	30.2083	2.1	30.2083	75.	30.2083	3.0
30.5417	-3.90	30.5417	.0	30.5417	88.	30.5417	10.0
30.8750	2.20	30.8750	5.1	30.8750	70.	30.8750	10.0
31.2083	1.10	31.2083	.0	31.2083	89.	31.2083	10.0
31.5417	.00	31.5417	3.1	31.5417	92.	31.5417	10.0
31.8750	4.40	31.8750	5.1	31.8750	57.	31.8750	10.0

Influent Flowrate data		Influent Temperature datc		Diffused Air Flowrate datc		Substrate Removal data	
DateTime	Influent Flowrc	DateTime	Influent Temp.	DateTime	Air Flowrate	DateTime	Sub. Removal
1.7083	108440.	1.7083	35.0	1.7083	21.	1.7083	73068.
2.7083	113285.	2.7083	36.1	2.7083	23.	2.7083	73406.
3.7083	112793.	3.7083	36.1	3.7083	23.	3.7083	90546.
4.7083	112793.	4.7083	36.7	4.7083	22.	4.7083	89138.
5.7083	118811.	5.7083	35.6	5.7083	21.	5.7083	93187.
6.7083	116162.	6.7083	36.7	6.7083	21.	6.7083	98973.
7.7083	112717.	7.7083	35.0	7.7083	21.	7.7083	91606.
8.7083	113891.	8.7083	36.1	8.7083	22.	8.7083	113059.
9.7083	110144.	9.7083	37.2	9.7083	22.	9.7083	112948.
10.7083	112036.	10.7083	36.1	10.7083	22.	10.7083	78172.
11.7083	111430.	11.7083	35.0	11.7083	23.	11.7083	77358.
12.7083	113891.	12.7083	35.6	12.7083	22.	12.7083	94260.
13.7083	112717.	13.7083	36.7	13.7083	22.	13.7083	83103.
14.7083	119265.	14.7083	35.6	14.7083	21.	14.7083	82168.
15.7083	116162.	15.7083	34.4	15.7083	23.	15.7083	107174.
16.7083	116919.	16.7083	34.4	16.7083	23.	16.7083	99920.
17.7083	109727.	17.7083	35.0	17.7083	23.	17.7083	86679.
18.7083	115405.	18.7083	35.0	18.7083	23.	18.7083	83424.
19.7083	113134.	19.7083	35.6	19.7083	2.	19.7083	89170.
20.7083	111695.	20.7083	35.6	20.7083	22.	20.7083	105587.
21.7083	112225.	21.7083	33.9	21.7083	22.	21.7083	85846.
22.7083	102611.	22.7083	35.6	22.7083	0.	22.7083	64917.
23.7083	116919.	23.7083	34.4	23.7083	22.	23.7083	86828.
24.7083	109916.	24.7083	34.4	24.7083	19.	24.7083	83239.
25.7083	109311.	26.7083	34.4	25.7083	22.	25.7083	56341.
26.7083	112036.	27.7083	33.9	26.7083	22.	26.7083	68911.
27.7083	106737.	28.7083	35.0	27.7083	22.	27.7083	66080.
28.7083	112755.	29.7083	36.1	28.7083	21.	28.7083	72407.
29.7083	114572.	30.7083	35.6	29.7083	22.	29.7083	90116.
30.7083	112490.	31.7083	36.1	30.7083	21.	30.7083	106416.
31.7083	116086.			31.7083	21.	31.7083	83138.

Number of Aerators data		Spray Area data		Solar Radiation Data	
DateTime	No. Aerators	DateTime	Spray Area	DateTime	Solar Radiation
1.7083	.0	1.7083	.0	1.2083	0.
31.7083	.0	31.7083	.0	31.2083	0.

Maine - July Input Files

Latitude	44.55
Longitude	70.54
Ground Temperature	18
Basin Surface Area	8977
Basin Volume	33522
Submerged Wall Area Exposed to Air	0
Heat Transfer Coefficient to Air	0
Submerged Wall Area Exposed to Groun	8977
Heat Transfer Coefficient to Ground	10000
Power Input to Aerator	0
Efficiency ofAerator	0
Power Input to Compressor	5000
Efficiency of Compressor	60
Cell Yield	0.42
Start Date	183.6667
Model Duration	30
Print Time Interval	0.25
Initial Basin Temperature Estimate	40

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
183.1667	15.00	183.1667	2.1	183.1667	54.	183.1667	.0
183.5000	19.40	183.5000	6.7	183.5000	32.	183.5000	.0
183.8333	23.90	183.8333	7.7	183.8333	23.	183.8333	4.0
184.1667	13.30	184.1667	3.1	184.1667	60.	184.1667	.0
184.5000	21.10	184.5000	2.6	184.5000	42.	184.5000	1.0
184.8333	23.90	184.8333	4.6	184.8333	39.	184.8333	8.0
185.1667	17.20	185.1667	2.6	185.1667	68.	185.1667	8.0
185.5000	17.80	185.5000	3.6	185.5000	58.	185.5000	10.0
185.8333	20.60	185.8333	3.6	185.8333	42.	185.8333	8.0
186.1667	13.30	186.1667	1.5	186.1667	75.	186.1667	1.0
186.5000	21.70	186.5000	2.6	186.5000	43.	186.5000	3.0
186.8333	22.20	186.8333	4.6	186.8333	43.	186.8333	10.0
187.1667	15.60	187.1667	2.6	187.1667	87.	187.1667	10.0
187.5000	17.80	187.5000	4.1	187.5000	81.	187.5000	10.0
187.8333	16.70	187.8333	3.6	187.8333	81.	187.8333	10.0
188.1667	15.00	188.1667	2.6	188.1667	97.	188.1667	10.0
188.5000	15.60	188.5000	4.1	188.5000	93.	188.5000	10.0
188.8333	17.80	188.8333	5.1	188.8333	78.	188.8333	10.0
189.1667	16.70	189.1667	2.6	189.1667	90.	189.1667	10.0
189.5000	17.20	189.5000	2.1	189.5000	97.	189.5000	10.0
189.8333	17.80	189.8333	4.6	189.8333	93.	189.8333	10.0
190.1667	16.70	190.1667	.0	190.1667	100.	190.1667	10.0
190.5000	18.30	190.5000	2.1	190.5000	100.	190.5000	10.0
190.8333	28.90	190.8333	3.6	190.8333	57.	190.8333	2.0
191.1667	19.40	191.1667	2.1	191.1667	68.	191.1667	.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
191.5000	20.00	191.5000	6.2	191.5000	41.	191.5000	.0
191.8333	23.30	191.8333	7.7	191.8333	31.	191.8333	.0
192.1667	15.00	192.1667	1.5	192.1667	56.	192.1667	.0
192.5000	21.70	192.5000	5.1	192.5000	46.	192.5000	3.0
192.8333	25.60	192.8333	6.2	192.8333	39.	192.8333	6.0
193.1667	16.70	193.1667	2.6	193.1667	67.	193.1667	4.0
193.5000	20.60	193.5000	4.1	193.5000	51.	193.5000	9.0
193.8333	23.90	193.8333	2.6	193.8333	42.	193.8333	9.0
194.1667	15.60	194.1667	2.1	194.1667	70.	194.1667	.0
194.5000	22.20	194.5000	4.6	194.5000	51.	194.5000	9.0
194.8333	22.80	194.8333	6.2	194.8333	48.	194.8333	10.0
195.1667	14.40	195.1667	2.1	195.1667	93.	195.1667	6.0
195.5000	17.20	195.5000	2.6	195.5000	87.	195.5000	10.0
195.8333	18.90	195.8333	3.1	195.8333	93.	195.8333	10.0
196.1667	16.70	196.1667	4.6	196.1667	97.	196.1667	10.0
196.5000	18.30	196.5000	6.7	196.5000	90.	196.5000	10.0
196.8333	23.90	196.8333	4.6	196.8333	58.	196.8333	10.0
197.1667	16.70	197.1667	3.1	197.1667	84.	197.1667	.0
197.5000	23.30	197.5000	5.7	197.5000	50.	197.5000	.0
197.8333	30.00	197.8333	5.1	197.8333	28.	197.8333	.0
198.1667	17.20	198.1667	2.6	198.1667	70.	198.1667	.0
198.5000	23.90	198.5000	3.1	198.5000	52.	198.5000	5.0
198.8333	26.70	198.8333	7.7	198.8333	44.	198.8333	10.0
199.1667	21.10	199.1667	4.1	199.1667	53.	199.1667	.0
199.5000	25.00	199.5000	3.6	199.5000	48.	199.5000	10.0
199.8333	32.20	199.8333	6.2	199.8333	35.	199.8333	7.0
200.1667	23.30	200.1667	2.1	200.1667	74.	200.1667	10.0
200.5000	27.20	200.5000	.0	200.5000	54.	200.5000	.0
200.8333	29.40	200.8333	5.7	200.8333	50.	200.8333	3.0
201.1667	19.40	201.1667	2.6	201.1667	90.	201.1667	5.0
201.5000	27.20	201.5000	.0	201.5000	65.	201.5000	1.0
201.8333	28.90	201.8333	4.6	201.8333	57.	201.8333	5.0
202.1667	24.40	202.1667	3.1	202.1667	67.	202.1667	5.0
202.5000	30.00	202.5000	3.1	202.5000	57.	202.5000	6.0
202.8333	31.70	202.8333	5.1	202.8333	55.	202.8333	4.0
203.1667	26.70	203.1667	2.1	203.1667	67.	203.1667	10.0
203.5000	28.90	203.5000	3.6	203.5000	59.	203.5000	10.0
203.8333	31.10	203.8333	4.6	203.8333	45.	203.8333	10.0
204.1667	21.70	204.1667	1.5	204.1667	73.	204.1667	.0
204.5000	22.80	204.5000	4.1	204.5000	62.	204.5000	.0
204.8333	23.30	204.8333	6.7	204.8333	58.	204.8333	9.0
205.1667	18.30	205.1667	3.1	205.1667	87.	205.1667	10.0
205.5000	18.90	205.5000	5.7	205.5000	100.	205.5000	10.0
205.8333	33.90	205.8333	5.1	205.8333	37.	205.8333	10.0
206.1667	25.60	206.1667	4.6	206.1667	64.	206.1667	7.0

Air temperature data		Wind Speed data		Relative Humidity data		Cloud Cover data	
DateTime	Temperature	DateTime	Wind Speed	DateTime	Humidity	DateTime	Cloud Cover
206.5000	26.10	206.5000	5.1	206.5000	45.	206.5000	2.0
206.8333	26.70	206.8333	4.6	206.8333	49.	206.8333	1.0
207.1667	19.40	207.1667	3.1	207.1667	57.	207.1667	.0
207.5000	23.90	207.5000	2.6	207.5000	52.	207.5000	6.0
207.8333	25.60	207.8333	5.1	207.8333	42.	207.8333	10.0
208.1667	20.60	208.1667	3.1	208.1667	73.	208.1667	10.0
208.5000	20.60	208.5000	2.1	208.5000	84.	208.5000	10.0
208.8333	19.40	208.8333	2.1	208.8333	97.	208.8333	10.0
209.1667	16.10	209.1667	.0	209.1667	97.	209.1667	10.0
209.5000	21.10	209.5000	2.6	209.5000	87.	209.5000	10.0
209.8333	26.70	209.8333	3.6	209.8333	42.	209.8333	10.0
210.1667	17.80	210.1667	2.1	210.1667	68.	210.1667	.0
210.5000	21.70	210.5000	5.1	210.5000	51.	210.5000	4.0
210.8333	25.00	210.8333	5.7	210.8333	43.	210.8333	9.0
211.1667	15.00	211.1667	.0	211.1667	78.	211.1667	.0
211.5000	21.70	211.5000	3.1	211.5000	59.	211.5000	8.0
211.8333	23.30	211.8333	4.1	211.8333	50.	211.8333	10.0
212.1667	14.40	212.1667	.0	212.1667	90.	212.1667	.0
212.5000	18.90	212.5000	3.1	212.5000	73.	212.5000	10.0
212.8333	21.70	212.8333	3.6	212.8333	48.	212.8333	9.0
213.1667	16.70	213.1667	2.1	213.1667	87.	213.1667	10.0
213.5000	19.40	213.5000	1.0	213.5000	78.	213.5000	10.0
213.8333	22.20	213.8333	6.2	213.8333	69.	213.8333	.0

Influent Flowrate data		Influent Temperature datc		Diffused Air Flowrate datc		Substrate Removal Rate	
DateTime	Influent Flowrat	DateTime	Influent Temper	DateTime	Air Flowrate	DateTime	Sub. Removal
183.6667	117600.	183.6667	39.4	183.6667	22.	183.6667	25591.
184.6667	119493.	184.6667	39.4	184.6667	21.	184.6667	34145.
185.6667	123278.	185.6667	40.0	185.6667	21.	185.6667	26982.
186.6667	125170.	186.6667	40.0	186.6667	21.	186.6667	31915.
187.6667	124792.	187.6667	40.0	187.6667	21.	187.6667	33152.
188.6667	121385.	188.6667	39.4	188.6667	21.	188.6667	27737.
189.6667	123656.	189.6667	40.0	189.6667	21.	189.6667	30316.
190.6667	120136.	190.6667	40.6	190.6667	21.	190.6667	28802.
191.6667	118471.	191.6667	39.4	191.6667	21.	191.6667	32661.
192.6667	111695.	192.6667	40.0	192.6667	21.	192.6667	26954.
193.6667	112528.	193.6667	40.0	193.6667	21.	193.6667	20846.
194.6667	108327.	194.6667	40.0	194.6667	21.	194.6667	33620.
195.6667	112112.	195.6667	40.6	195.6667	21.	195.6667	33324.
196.6667	116313.	196.6667	38.9	196.6667	21.	196.6667	31347.
197.6667	112869.	197.6667	40.6	197.6667	21.	197.6667	31487.
198.6667	115064.	198.6667	40.0	198.6667	21.	198.6667	32476.
199.6667	125359.	199.6667	41.1	199.6667	21.	199.6667	31062.
200.6667	117259.	200.6667	41.1	200.6667	20.	200.6667	28126.
201.6667	121915.	201.6667	41.7	201.6667	20.	201.6667	33048.
202.6667	121574.	202.6667	42.2	202.6667	20.	202.6667	29060.
203.6667	122672.	203.6667	42.2	203.6667	20.	203.6667	27677.
204.6667	130696.	204.6667	41.7	204.6667	21.	204.6667	27710.
205.6667	120250.	205.6667	40.0	205.6667	20.	205.6667	29107.
206.6667	115102.	206.6667	41.1	206.6667	20.	206.6667	24299.
207.6667	90310.	207.6667	37.2	207.6667	21.	207.6667	14745.
208.6667	98486.	208.6667	37.2	208.6667	21.	208.6667	15132.
209.6667	114042.	209.6667	42.2	209.6667	21.	209.6667	25617.
210.6667	118206.	210.6667	42.2	210.6667	20.	210.6667	27032.
211.6667	114042.	211.6667	41.1	211.6667	21.	211.6667	28988.
212.6667	98145.	212.6667	41.1	212.6667	21.	212.6667	23446.
213.6667	114345.	213.6667	42.2	213.6667	21.	213.6667	49104.

Spray Area data		Solar Radiation Data		Number of Aerators data	
DateTime	Spray Area	DateTime	Solar Radiation	DateTime	Number of Aerators
183.6667	.0	183.1667	0.	183.6667	.0
213.6667	.0	213.1667	0.	213.6667	.0