Comprehensive Modeling and Real Time Control Strategies

Strategy Development for Wastewater Treatment Plant Process and Process Control Models

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Date: December 13, 2002

1.0 Introduction

Two wastewater treatment plants (WWTPs), Jones Island and South Shore, serve the Milwaukee Metropolitan Sewerage District (District). When addressing the capacity of the WWTPs, two capacities are discussed: the process and hydraulic capacity. The hydraulic capacity refers to the maximum flow rate that is physically possible to pass through the various hydraulic elements comprising the liquid treatment trains at the two WWTPs. For any given flow scenario, defined by all the piping, channeling, tanks, etc., used to convey the influent flow through the WWTP to Lake Michigan at a set elevation, the hydraulic capacity will be a fixed flow rate defined by the maximum flow rate through whichever unit process limits overall hydraulic capacity. However, the capability to divert around certain unit processes, the capability to take tanks in and out of service, and the changing elevation of Lake Michigan contribute to the possibility of numerous flow scenarios. Models simulating all the possible flow scenarios to determine the hydraulic capacity of the WWTPs are discussed in an accompanying model strategy document. Process capacity refers to the maximum flow or loading beyond which an individual unit process cannot meet its process objective.

This document summarizes the District’s needs and goals for WWTP process models, identifies models used on previous District projects, summarizes essential attributes of the models, presents an evaluation of model strategies, and provides recommendations for the model strategy that best satisfies the identified needs, goals, and criteria. The recommended primary model strategy is to use the state point analysis for Real Time Control (RTC) estimates of the secondary clarifier capacity, and BioWin as a biological simulator for planning purposes.
2.0 District Needs
Specific needs of the District for WWTP models are to:

- Accurately predict effluent quality for different future loading conditions, discharge requirements, and treatment scenarios
- Accurately predict the mixed liquor suspended solids (MLSS) concentrations for different future loading conditions, discharge requirements, and treatment scenarios
- Accurately predict the process capacity of the secondary clarifiers at the WWTPs
- Determine the maximum treatment capacity at the current or near-term loading conditions
- Accurately predict sludge settleability either deterministically (models currently unavailable) or stochastically

Short-term modeling needs of the District include evaluating impacts for taking WWTP unit processes off-line, such as for maintenance purposes, and evaluating alternatives for operating strategies, such as maximizing wastewater treatment during storm events. In addition, the model also may be used as a training tool for operators.

Long-term modeling needs of the District include facility planning, maximizing wastewater flow through the plants while minimizing effluent quality excursions, and evaluating alternatives for plant improvements, such as sizing new facilities, evaluating different facility arrangements, and determining interactions between all existing and new facilities.

3.0 Essential Attributes
Attributes considered essential to meet District requirements for the WWTP model strategy include:

- Adjusting to changes in the system (versatile, adaptable)
- Evaluating pollutant removal through each unit process
- Calibrating or comparing models with actual facility performance
- Evaluating biosolids generation
- Simulating steady-state and dynamic flow and load scenarios
- Providing long- and short-term simulations
Modeling “critical” control mechanisms

Using Chemical Oxygen Demand (COD) based calculations for biological process models, which will allow for a mass balance. This is impossible to do using Biochemical Oxygen Demand (BOD), which has been historically used at the District.

4.0 Required Model Resolution

WWTP models must have sufficient resolution to determine maximum flow through the WWTP while minimizing effluent quality excursions. The model resolution depends on whether the District has site-specific, detailed design needs that require higher model resolution or immediate, operational modeling needs that model plant operations using the main components of the WWTP process models, but with lower resolution. General model resolution requirements are that the model resolution must:

- Coincide with the resolution of the active unit processes
- Coincide with the resolution of the wastewater flows
- Correspond to the level of definition of the model (planning versus detailed design needs)

5.0 Current Applicable District Models

As outlined in Comprehensive Modeling and Real Time Control Strategies Technical Memorandum No. 2.1 – Historical Model Review (CDM, 2002), the District currently uses state point analyses to determine on-line secondary clarifier capacity and BioWin for biological process simulation.

5.1 State Point Analysis

For RTC models, District WWTP operators use a state point analysis model to determine on-line secondary clarifier capacity. This model was developed by United Water Services (UWS) and generates the requisite settling flux curve based on the measurement of the Sludge Volume Index (SVI). To compensate for the inaccuracies in the state point analysis model, the SVI value used as input into the model is the most recently measured SVI plus 25 milliliters per gram (mL/g). The SVI is measured once per shift.

Model Versus District Needs

The existing method for determining SVI is to take the most recent measurement and then add 25 mL/g as a factor of safety.

Model Limitations

There is a time delay in determining the process capacity because values are based on actual measurements. This is a problem when immediate decisions regarding process capacity must
be made before or during storm events. In addition, adding 25 mL/g to the most recent SVI measurement may be too conservative of an estimate. However, more importantly, the current model does not address:

- The flow distribution of MLSS to the two sections of the treatment plants (east and west)
- The distribution of flow to the individual clarifiers
- Control of the Return Activated Sludge (RAS) systems

5.2 Biological Simulator Model
The District currently uses the activated sludge simulator, BioWin, to simulate biological activity in the liquid treatment train at the WWTPs. BioWin is a biological wastewater treatment process simulation model that is currently used to evaluate the wet weather treatment capacity of the Jones Island and South Shore WWTPs, particularly for planning purposes.

Model Versus District Needs
When properly calibrated and verified, BioWin can predict the biological activity at a WWTP with a high degree of accuracy. Output from BioWin can be used for sizing secondary clarifiers, for sizing waste activated sludge treatment units, for determining aeration requirements, for determining the impact of additional or fewer process units, and for predicting effluent quality.

Model Limitations
The accuracy of BioWin, properly calibrated and verified, satisfies the District’s biological modeling needs. However, the secondary clarifier modeling options available in BioWin suffers from the same shortcomings of a state point analysis. That is, it assumes ideal flow and ideal sludge pickup, flocculation is not modeled, and there is no method to simulate any hydraulic inefficiencies.

6.0 Model Interface
WWTP process models will interface with a Supervisory Control and Data Acquisition (SCADA) System, Geographic Information Systems (GIS) data, databases, Computer Aided Design (CAD), and the Central Data Management System (CDMS) which is being developed as part of the 2020 Facilities Plan. In addition, District WWTP process models will interface with models that provide input to and receive output from the model types indicated in Tables 1 and 2, respectively. A schematic of the WWTP modeling components and interfaces are in Figure 1. Specific model input and output data requirements are detailed in the WWTP Process Implementation Plan, located in the Appendix of the Comprehensive Modeling
Table 1. Interface of Models that Potentially Provide Input to WWTP Process Models

<table>
<thead>
<tr>
<th>Modeling Application</th>
<th>Current Model</th>
<th>Input to WWTP Process Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWTP Hydraulics</td>
<td>None</td>
<td>Time series of wastewater flows</td>
</tr>
<tr>
<td>Sewage Quality</td>
<td>None</td>
<td>Time series of incoming pollutants, solids and oxygen concentrations</td>
</tr>
</tbody>
</table>

Table 2. Interface of Models that Potentially Receive Output from WWTP Process Models

<table>
<thead>
<tr>
<th>Modeling Application</th>
<th>Current Model</th>
<th>Output from WWTP Process Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Water Quality</td>
<td>None</td>
<td>Final concentrations of indicator parameters (BOD, total suspended solids (TSS), Chlorine, etc.) discharged from WWTPs</td>
</tr>
<tr>
<td>Decision Support</td>
<td>None</td>
<td>Identification of unit processes that exceed capacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Locations of &quot;bottlenecks&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removal effectiveness of pathogens, sediment, and pollutants for each unit process</td>
</tr>
</tbody>
</table>

7.0 Model Strategy Selection
During the facility planning activities the District will soon be embarking on, the process capacity necessary to treat future flows and loads for all unit processes at the two WWTPs will have to be determined and modifications or additions made accordingly. For example,
the air requirement needed to treat future organic loads may dictate that additional blower
capacity is needed or the excess activated sludge produced in treating these future organic
loads may dictate additional thickening facilities are necessary. For high-flow, storm-induced
events, the primary focus is on the process capacity of the liquid stream treatment process
units. Because of the relatively short duration of these peak flow events, the process
capacities of the solids stream treatment process units are not a major concern. According to
UWS, “peak loadings can occur during peak hydraulic events. These events can produce
both organic and inorganic peak loadings to the preliminary and primary treatment
processes, and are dependent on the length of the previous dry weather period. Overload of
these two processes can have a domino effect on the secondary treatment process.” In
addition, the primary clarifier facility in the South Shore WWTP is currently “undersized for
the maximum hydraulic loading. The preliminary and primary processes have been a major
process limitation for both WWTPs and the District has been addressing this limitation in the
Capital programs” (Dineen, 2002). Based on past experience at the District’s two WWTPs, the
secondary clarifiers are the process limitation during peak flow events. That is, the secondary
clarifiers, during peak flow events, are prone to fill up with activated sludge solids to the
point that a gross loss of solids into the secondary effluent is imminent. If solids loss occurs,
an effluent TSS violation is likely. By definition, this result indicates the process capacity of
the secondary clarifiers (i.e., their ability to separate the biological solids from the treated
effluent) has been exceeded. To prevent this from happening, primary effluent flow is
diverted around the secondary process and blended with secondary effluent before being
disinfect and discharged. The process capacity of secondary clarifiers (i.e., how much flow
can be contained without exceeding their process objective of separating biological solids
from treated effluent and meeting permit requirements) is a function of:

1. The MLSS concentration
2. The settling characteristics of the mixed liquor
3. The total on-line secondary clarifier surface area
4. The RAS flow rate
5. The hydraulic characteristics of the secondary clarifiers

The sludge settleability and the MLSS concentration are important in defining the capacity of
the secondary clarifiers. While biological simulator models, such as BioWin, can predict with
reasonable accuracy the MLSS concentration, currently, there are no commercially available
modeling tools that predict sludge settleability deterministically. It is impossible, therefore, to
consider a planning-level model for predicting sludge settleability. For purposes of RTC
models, different stochastic models can be developed for predicting sludge settleability.
However, because of the availability of on-line instrumentation for measuring both the MLSS
concentration and sludge settleability (e.g., on-line sludge volume index, or SVI, measurements), the need for RTC predictions of these parameters is not necessary.

For operational RTC, especially during periods of high flows, the biological process modeling software (e.g., BioWin, EFOR, GPS-X, MATLAB & Simulink, SIMBA, STOAT, WEST) has two important shortfalls: (1) none of them predict sludge settleability, and (2) prediction of the MLSS concentration is moot because it is the measurable MLSS concentration as the high flow event begins that is important. A current wet weather flow strategy being implemented at the two plants is to turn off the air to some of the aeration basins so they can capture solids. This causes the MLSS concentration to change constantly. Therefore, on-line measurement of the MLSS concentration and sludge settleability going to the secondary clarifiers should be considered. A secondary clarifier model could be used with these on-line measurements, as suggested in Figure 1.

Figure 1 also shows the conceptual relationships between the hydraulic, process, and secondary clarifier models. While the secondary clarifier models can also be considered “process” models, the distinction between the two is made in this document because of the prominent role the secondary clarifiers play in limiting the process capacity of the two WWTPs. The difference between the comprehensive modeling needs of the District (i.e., facility planning modeling needs) and the RTC modeling needs of the District also should be noted. Comprehensive models will require future predictions of all the District’s wastewater treatment needs based on future growth, flows, and loadings and not every unit process will be able to be modeled deterministically.

### 7.1 Criteria

Criteria for evaluating the modeling approach and random applicable software were based on the criteria detailed in *Comprehensive Modeling and Real Time Control Strategies Technical Memorandum No. 2.2 – Model Strategy Development Criteria* (CDM, 2002).

### 7.2 Modeling Tools

Only planning model strategies that satisfied the essential attributes previously mentioned for WWTP process modeling were evaluated. Modeling tools such as stochastic and deterministic models for predicting sludge settleability, the state point analysis and Computational Fluid Dynamics (CFD) for estimating secondary clarifier capacity, and biological simulator modeling are discussed. Software considered for biological simulator modeling included BioWin, GPS-X, EFOR, and STOAT.

#### 7.2.1 Predicting Sludge Settleability

Currently, no deterministic models are available to predict sludge settleability. A sludge settleability, or SVI, prediction model would allow input besides just the measured values, therefore, allowing more frequent and timely updates. Instrumentation is available to
measure SVI on an automatic, semi-continuous basis, providing a stochastic-based prediction. Although sludge settleability can only be predicated stochastically, a deterministic prediction modeling tool would be preferred if one were available.

**Stochastic Model**
Sludge settleability can be predicted using a stochastic model. The stochastic model takes actual measurements and builds prediction relationships based on these measurements. Stochastic models (e.g., neural networks) may be applicable for predicting sludge settleability for on-line control but would not be applicable for facility planning modeling. A limitation to stochastic models is that they require actual measurements and, therefore, a processing delay may occur.

**Deterministic Model**
A deterministic model for predicting sludge settleability would provide a formulated method for predicting sludge settleability. To our knowledge, currently, no deterministic process models will predict sludge settleability, but potentially, these models could be developed.

### 7.2.2 Secondary Clarifier Models
Process models need to focus on the sludge quality, such as flocculation, settling, and compacting characteristics. Identifying the quality of the sludge is necessary to maximize flow to the secondary clarifier(s). Modeling the process decreases the variability in the SVI and reduces the average SVI. Currently, there are two modeling tools for estimating secondary clarifier capacity: the state point analysis and CFD.

**State Point Analysis**
The state point analysis, based on solids flux theory, is a one-dimensional secondary clarifier model that requires as input measurements of the secondary flow rate, the MLSS concentration, the RAS flow rate, and the on-line secondary clarifier surface area. It is the understanding of the Comprehensive Modeling Team that the activated sludge process simulators (e.g., BioWin, GPS-X EFOR, STOAT,) use either a state point analysis or a modified form of a state point analysis in their simulation of secondary clarification. The state point analysis takes the most recent measurements and predicts the capacity of the secondary clarifier. This method is easy to use and quickly estimates a result, therefore, making it very useful for RTC simulations.

Limitations of the state point analysis are that it requires actual measurements, which may have a processing delay, and it only looks at the most basic conditions within the secondary clarifier. A state point analysis model is very idealized in the sense that water and solids movement in the secondary clarifier occurs only in the vertical direction; inefficiencies caused by horizontal movement and other hydraulic characteristics are not taken into account. Full-scale stress testing of the modified clarifiers was performed in the fall of 2002 as part of the current Jones Island Wet Weather Capacity Project (Dineen, 2002). This testing will compare
the magnitude of the theoretical capacity predicted by a state point analysis and the actual capacity.

**Computational Fluid Dynamics**

The hydraulic characteristics of secondary clarifiers are taken into account in a number of two- and three-dimensional models based on CFD. These models use the laws of conservation of mass and momentum and various fluid properties to model flow through a clarifier of set dimensions. For example, CFD analyzes density currents and eddy currents within the clarifier. The “off-the-shelf” availability of these models is questionable. Those CFD models that are commercially available require extensive code manipulation for application to secondary clarifiers. Several engineering consulting firms have developed CFD programs that are proprietary. In addition, CFD is more computationally challenging than a state point analysis, and current CFD models do not take into account flocculation reactions occurring in the mixed liquor and typically use the SVI to describe sludge settleability. Correlations used in the CFD models to describe sludge settleability using SVI may not be applicable at the Jones Island and South Shore WWTPs.

The most appropriate use of CFD modeling at the District is for designing future performance-enhancing modifications to the existing clarifiers. CFD models can be used to evaluate different design modifications without implementation. For this reason, CFD models are significantly more appropriate than installing a modification and doing a comparable stress test.

**7.2.3 Biological Simulator Models**

There are a number of biological process simulators (e.g., BioWin, EFOR, GPS-X, SIMBA, STOAT, WEST) that predict, among other things, the MLSS concentration in the activated sludge system, all of which are ultimately based on the Activated Sludge Model No. 1. The MLSS concentration is a function of the organic load to the activated sludge process, the wastewater temperature, the total on-line aeration tank volume, and the solids residence time (also known as the mean cell residence time and sludge age). The main focus of the biological process simulators is the activated sludge process (i.e., the biological reactor and secondary clarifier), although some of them also include models of, for example, primary clarifiers, different thickening processes, and aerobic and anaerobic digestion.

All of the evaluated biological process modeling software are commercially available and allow either the designer or the WWTP operator to identify process bottlenecks, optimize operations, reduce operation costs, simulate altered WWTP operations during rain, industrial holidays, or other external events, and facilitate day-to-day decision making for the WWTP. Each of the software packages includes COD-based solving mechanisms and satisfies the relevant essential attributes.
7.3 Ranking of Modeling Tools

Definitions and rating methodology are explained in Table 3. Model strategies are rated according to general criteria in Table 4. No criterion matrices were developed for the Sludge Settleability Prediction modeling tools (stochastic and deterministic models) and Secondary Clarifier modeling tools (state point analysis and CFD) because the evaluated tools are used for different purposes: the stochastic method is used for operational purposes whereas the deterministic model, if it were available, would be used for planning purposes; the state point analysis is used for operational RTC modeling and CFD is only used for planning.

Only BioWin, GPS-X, STOAT, and EFOR were evaluated for this model strategy document. As indicated in Table 4, the evaluated software are very comparable and have nearly equal ratings. The primary differences between BioWin, GPS-X, STOAT, and EFOR are as follows:

- **BioWin** is the District’s current biological process modeling software, and has more deterministic foundation than the other evaluated biological process modeling software.

- **GPS-X** is available in four main configurations: Entry level, Standard, Professional, and Enterprise, each aimed at users with different needs and resources. In addition, GPS-X has customizable, open model code that allows users to change models, change interface forms, and add new models.

- **STOAT** has an agreement with UWS, the contract operator of the District WWTPs, that UWS will use the STOAT software exclusively for WWTP operations modeling. STOAT integrates directly with sewer models produced by Danish Hydraulic Institute, Inc. (DHI) (i.e. MOUSE) and Wallingford Software (InfoWorks Collection System).

- **EFOR** is supported and maintained by the DHI, which also supports and maintains MOUSE, the District’s current sewer hydraulics modeling software. EFOR can be integrated with a SCADA as an on-line model or used as an educational tool. In addition, EFOR is integrated with MOUSE and MIKE 11, providing dynamic and simultaneous simulations on the sewer system, the treatment plants, and the receiving waters.

In 2002, the European Cooperation in the Field of Scientific and Technical Research published a comparison study of BioWin, EFOR, GPS-X, MATLAB & Simulink, SIMBA, STOAT, WEST (Copp, 2001). This study provides a more in-depth comparison of these biological process models, covering simulator description, model issues, simulation issues, and basic control strategy.

The District should continue to use BioWin because it has a more deterministic foundation than the other biological simulator modeling tools and because it has been historically been used by the District.
8.0 Strategy Recommendation

Although all of the evaluated model strategies satisfy the majority of the District’s WWTP Process modeling needs and goals, it is recommended that the District:

1. Continue using the state point analysis model to make RTC estimates of secondary clarifier capacity.

2. Confirm the applicability of the SVI correlation used to generate the settling flux curve used in the state point analysis model.

3. Quantify the disagreement between the theoretical secondary clarifier capacity predicted by the state point analysis model and actual by conducting stress tests after the current clarifier improvements projects are completed; if possible, modify the state point analysis model to compensate for this disagreement so a more accurate prediction of secondary clarifier capacity is possible.

4. Continue to use BioWin for modeling biological processes. BioWin is more firmly grounded with deterministic relationships than the other biological simulation software packages, giving more accurate results. Perhaps more importantly, the District already uses BioWin for modeling biological processes, and the leasing option available with BioWin makes it more accessible to others. The use of any biological process model for RTC is relatively uncharted territory. However, BioWin can be a strategic planning tool such as for evaluating future loading scenarios.

5. Because the secondary clarifiers are the process bottlenecks at both the District’s WWTPs, install on-line instrumentation to measure sludge settleability and mixed-liquor suspended solids (MLSS) concentration (inputs to the state point analysis model); investigate the use of stochastic models for predicting sludge settleability.

6. Use computational fluid dynamic models to design future performance-enhancing modifications of the secondary clarifiers.

These recommendations refer to both of the District’s WWTPs: Jones Island and South Shore.

The remainder of this document focuses on the model development and maintenance effort, model user competency, regulatory agency acceptance, and model availability to future District consultants for using the state point analysis to make RTC estimates of secondary clarifier capacity and using BioWin for modeling biological processes.

8.1 Model Development and Maintenance Effort

The model development and maintenance efforts, as well as Quality Assurance/Quality Control (QA/QC) protocols, are discussed in detail in the WWTP Process Implementation
8.1.1 Model Development

Initial development is the creation of a model specific to the District’s wastewater and WWTPs and may include entering data inputs, pre-processing input data, reviewing software defaults, and calibrating and verifying the model.

State Point Analysis
Data that will be needed for the initial development of state point analyses include flows to the secondary clarifiers, surface area of and number of on-line secondary clarifiers, MLSS settleability, and the RAS flow rate.

The state point analyses should be verified against stress tests and, possibly, a three-dimensional model. The level of effort required for state point analyses include gathering on-line measurements every 30 minutes, and analyzing the results, which takes a few minutes for each measurement.

Biological Simulator Models (BioWin)
Data that will be needed for the initial development of biological simulator models, using BioWin, include a thorough and accurate characterization of the incoming wastewater, recycled or RAS flows, Waste Activated Sludge (WAS) flows, blower capacities, outfall flows, dimensions of unit process (length, width, surface area, and/or volume), and depth of flows through unit processes. In addition, nitrification rates, and wastewater temperature, and soluble and particulate, biodegradable and non-biodegradable fractions of COD and nitrogen need quantification.

The biological simulator models should be calibrated and verified with measured wastewater concentrations. The level of effort to develop a biological simulator model ranges from a few hours to several days, depending on the size and complexity of the WWTP.

8.1.2 Model Maintenance

State Point Analysis
The state point analysis is regularly maintained, as a new state point analysis is conducted every 30 minutes. Results from these analyses should be stored in the CDMS every 45 minutes.

Biological Simulator Models
Data used for model inputs must be updated to the most current available. Such data may include revising flow data, changing initial values for indicator parameters, and modifying dimensions and parameters for unit processes. These data will also require updates at the
beginning of a design or study of a WWTP and after significant changes are made to the physical system. Examples of significant changes include:

- Permanently installing or removing a unit process
- Permanently modifying the treatment procedures within a unit process
- Adding a large industrial facility to the service area
- Changes in acceptable discharge quality regulations
- Flow or load changes of 20 percent of current design value

It is recommended that a virtual “bulletin board” be maintained within the CDMS. Changes to the data in the CDMS should be recorded on the virtual bulletin board. Before using a model, model users should check this bulletin board for changes.

8.2 Model User Competency
As with all models, it is possible to obtain reasonable looking output from seriously erroneous input. Therefore, only competent users should develop and analyze models.

8.2.1 Competency Required
A competent user of a state point analysis model for secondary clarifier process evaluation is one who understands:

- The development of a settling flux curve
- The components of a state point analysis
- The movement of solids between the aeration basin and a secondary clarifier in an activated sludge process

A competent user of BioWin is one who understands:

- The COD, BOD, nitrogen, and phosphorus partitioning in activated sludge influents
- The kinetic relationships and parameters inherent in the model
- The manipulation of flows and pollutant loadings and other inputs into the model

All models must be subject to an independent QC review by an individual who is competent in all of the recommended WWTP process modeling tools.
8.2.2 Competency Available

Potential users of BioWin models and state point analyses are District staff members, UWS plant operators, consultants, and possibly regulators. A number of District staff has BioWin and state point analysis modeling experience. Currently, UWS operators have used the state point analysis for operations and decision support. Consultants routinely use biological simulator models and state point analyses.

Therefore, the existing available competency is adequate for performing state point analysis and BioWin modeling.

8.3 Regulatory Agency Acceptance

There are no modeling standards or preferred software by the Wisconsin Department of Natural Resources (WDNR) or the United States Environmental Protection Agency (U.S. EPA), and the acceptability by regulatory agencies of the evaluated software is currently unknown. However, in the future the Environmental Technology Verification (ETV) program, sponsored by the U.S. EPA, may serve as a source of regulatory approved model types. In addition, the approach for WWTP process modeling recommended in this document was reviewed by regulatory agency staff who served as members of the Model Strategy Advisory Committee.

8.4 Availability of Model to Future District Consultants

The District has operational and planning models that will preferably be made available to consultants.

*State Point Analysis*

The measurements, analysis procedure, and past results used to estimate the maximum secondary clarifier process capacity will be available at the discretion of the District and UWS.

*Biological Simulator Models*

BioWin is a commercially available software package and would be limited to consultants that could afford to either purchase or lease a license. BioWin typically costs $6,000 for one license, but a license can be leased for $1,500 per year (with a three-year minimum contract).
References


Dineen, Dennis (United Water Services). E-mail to Steve Heinz (MMSD) regarding RTC WWTP Modeling needs – draft report. October 4, 2002.

http://www.dnr.state.wi.us/NaturalResources.html


http://www.envirosim.com/

http://www.epa.gov/

http://www.hydromantis.com/

http://www.scitrav.com/wwater/waterlnk.htm

http://www.wrcgroup.com/products.htm
Figure 1. Relationships between process, secondary clarifier, and hydraulic models showing logic to determine maximum WWTP flow.

*Note - During high flows up to 60 MGD of flow from the Inline Storage System (ISS) can be pumped directly to disinfection, bypassing primary and secondary treatment.